UNITED STATES
DEPARTMENT OF THE INTERIOR
HAROLD L. ICKES, Secretary

FISH AND WILDLIFE SERVICE
IRA N. GABRIELSON, Director

Special Scientific Report No. 18

FISHERY MANAGEMENT

By

William C. Herrington and Robert A. Nesbit

(With an Introduction by Ira N. Gabrielson)

Chicago
1943

Explanatory Note

The series, Special Scientific Reports, embodies results of investigations, usually of restricted scope, intended to aid or direct management or utilization practices and as guides for administrative or legislative action. It is issued in limited quantities for the official use of Federal, State, or cooperating agencies and in processed form for economy and to avoid delay in publication.

This number was prepared primarily for the use of the Atlantic States Marine Fisheries Commission, established by an interstate compact ratified by act of Congress approved by the President May 4, 1942 (Public No. 539, 77th Congress), and its Advisory Committees. It presents in somewhat modified and extended form the addresses of the principal speakers in a "forum discussion" of fishery management at the regular meeting of the Commission on December 9, 1942 at Baltimore, Md.

UNITED STATES
DEPARTMENT OF THE INTERIOR
Fish and Wildlife Service
Chicago

FISHERY MANAGEMENT

A Forum Discussion of Principles and Methods of Fishery Management
Presented before the Atlantic States Marine Fisheries Commission,
December 9, 1942, Baltimore, Maryland.

By

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(With an Introduction by Dr. Ira N. Gabrielson,
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TABLE OF CONTENTS

Page

Introduction to the Forum Discussion on Fishery Management, by Ira N. Gabrielson..... 1

Some Methods of Fishery Management and Their Usefulness in a Management Program, by William C. Herrington..... 3

Biological and Economic Problems of Fishery Management, by Robert A. Nesbit..... 23

Rebuttal: Comments on Mr. Nesbit's Statement, by William C. Herrington..... 55

Comments on Mr. Herrington's Statement, by Robert A. Nesbit..... 61

Biographical Data..... 69

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INTRODUCTION TO FORUM DISCUSSION ON FISHERY MANAGEMENT

By Ira N. Gabrielson

This forum discussion of fishery management is held as a result of a motion passed at a meeting of the Atlantic States Marine Fisheries Commission on September 18, 1942, in New York City. According to minutes of that meeting, "It was agreed that the Commission recognize the seriousness of overcompetition in the fishing industry in normal times and that it request the Fish and Wildlife Service to report upon the feasibility of management plans and in cooperation with a special committee of the Commission to be appointed subsequently that it evolve an appropriate program for submission to the Commission."

This motion subsequently was considered by the Executive Committee, meeting on the same date, and it was agreed that in view of the divergent views held by the Commission's various technical advisors and the divergencies among the States, it would not be practicable to set up a single model plan at this time. The Fish and Wildlife Service was therefore invited to stage a forum or panel discussion by members of its staff in which the problems involved could be explored at length and placed before the Commission as a body. The special committee of the Commission could then be created to study the matter further with a view to making recommendations ultimately to the Commission.

The Executive Committee expressed the opinion that this topic was one on which several years of study would have to be spent before any conclusion could be reached but that it was important to begin such a study at once so as to have a program ready for adoption when peace comes.

Personally, I can agree heartily with the Executive Committee that it is important to begin such a study at once and that it will require several years to reach valid conclusions. I do not agree, however, that no conclusions can be reached and that no action should be taken to establish at least the broad outlines of a fishery management program until such an extended study has been completed. I believe it highly important that we attempt to understand the fundamental principles as fully as our present knowledge permits and that specific provisions for fishery regulation in accordance with our current understanding should be adopted even during wartime and before we are too greatly distracted by the urgencies of post-war reconstruction and adjustment. The Fish and Wildlife Service has accepted the invitation of the Commission, therefore, to hold this forum discussion at the first opportunity since the original request was made, believing that the problems are so urgent as to brook no further delay in seeking practical solutions.

In my first address to this Commission, on the occasion of its organizational meeting in New York on June 5, 1942, I stated that the task of this Commission will never be finished. One measure of its success will be how honestly it seeks solutions of its problems by the scientific method of trial and experiment, how criticially it observes the effects of its trial measures,

and how quickly it abandons old procedures and adopts new ones on the basis of experience. I pointed out that our knowledge of the fisheries is not adequate and the facts on which judgments must be based are so obscure and so diverse that it is easy to see why there are differences of opinion on the subject of management. I assured you that I shall not attempt to impose my own views and prejudices upon my official subordinates nor dictate "official policy" in scientific matters, for to do so would tend to stifle progress in finding new and better solutions as additional facts are discovered and greater experience is gained.

The discussion of the principles and practices of fishery management will be presented this evening from two divergent points of view by members of our scientific staff who have had long experience in the field of fishery biology and close and practical association with the fisheries and the fishermen. They have thought long and deeply on the subject of promoting the welfare of the fisheries. Doubtless you will note a very general agreement on the basic facts and on the general biological principles which underlie any system of management. This should give you increased confidence in the soundness of fishery science as a basis for guiding our practical actions. Fishery science has developed both in Europe and in America for a period of more than 50 years and is based on a great body of factual knowledge which has been accumulating for centuries. The integration of these facts and the deduction of the laws of nature that affect the fisheries has resulted in the founding of a distinct field of science, fishery biology. Following the lead of the European scientists, American investigators were quick to adopt the new techniques and concepts. In the past decade or so, they have forged ahead and now are regarded as world leaders in the field. We may, therefore, place great confidence in the scientific aspects of their work.

In the course of these discussions, however, you will also be aware of a fundamental divergence of opinion regarding the interpretation of certain facts and more particularly in the purely personal or emotional responses toward these interpretations which lead to action. These differences in reaction to established facts are as fundamental as the differences in personalities between each of us--differences based on our individual backgrounds, experiences, situations, aims, and outlook. I am very hopeful, however, that despite these personal reactions the spirit of compromise, which is the essence of democratic Government, will prevail in choosing a course of action based on reasoned judgment rather than on feeling and that the free discussion of opposing points of view which we have planned tonight will be the means of finding a common ground upon which we all can proceed with confidence.

The two principal speakers will present no debate on the merits of a specific proposal. They will not seek to influence you, as a jury is influenced, by oratory or forensics, but rather will attempt to present the facts and to analyze them carefully for your consideration. Although time has been given each of the principal speakers for rebuttal, such rebuttal will consist more properly of further discussion of any of the points which either speaker has presented. Following the main presentation, we shall welcome free discussion from the floor, for our purpose is to consider all aspects of the problem as a guide to practical and effective action. - - - .

SOME METHODS OF FISHERY MANAGEMENT AND THEIR USEFULNESS IN A MANAGEMENT PROGRAM

By William C. Herrington[1/]

For the last 75 years and more, the coastal peoples of the world have been concerned actively with the problem of maintaining their supplies of fish at a productive level. Despite this concern, only limited progress has been made in solving the problem. Such progress has been limited partly by the difficulty in overcoming the long and widely-held belief that the resources of the sea are inexhaustible and therefore cannot be affected by the activities of man[2/], and partly by the lack of knowledge and technical methods needed to solve the very complex problems involved. Even now we are but beginning to make headway in this field and there is as yet no

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1/ See p. 69 for biographical data.

2/ At the Fourth International Fishery Congress in 1908, during the discussions on menhaden, Professor Goode was quoted to the effect that he estimated a million, million of millions of menhaden (10^{18}) were killed annually by natural enemies. Goode considered this only an approximate estimate. W. F. Hathaway's paper, read at the same meeting, indicated that both Dr. Hugh M. Smith and Professor Baird approved of this general figure and the reasoning by which it was deduced. I have made some calculations using Goode's estimate. At one pound each, 10^{18} menhaden weighing 70 pounds per cubic foot, would require about 1.4×10^{16} cubic feet of space. A section of ocean on the continental shelf, one mile square and averaging 50 fathoms deep, would include about 10^{10} cubic feet. Thus, if the 10^{18} menhaden were packed solid, it would require about $1.4 \times 10^{16} \div 10^{10} = 1,400,000$ square miles of continental shelf with an average depth of 50 fathoms to provide room for them. Since the total area of the continental shelf inside the 100 fathom curve, from the Gulf of Maine to the southern tip of Florida, is much less than 100,000 square miles, it would seem that Professor Goode's "approximate estimate" was a little extravagant.

More recently, the head of a large fishing company told me of a case in which 20 haddock were removed from one monkfish. Making the apparently conservative assumption that there were at least 10 million monkfish on Georges Bank, he calculated that with each eating 20 haddock a day, 365 days a year, they destroyed altogether about 73 billion haddock annually. He maintained that in addition, other enemies destroyed additional billions. Our data indicate that in the peak year the total population of market size haddock on this bank was only 300 - 400 million. Thus, his estimate of haddock killed each year by monkfish alone, was about 200 times as great as the total adult haddock population.

These examples illustrate the general beliefs concerning the limitless numbers of fish in the sea, and how these beliefs have been encouraged by faulty deduction based on insufficient or erroneous observations.

generally accepted philosophy to guide the practical application of the results of technical research work. Our discussion this evening is an attempt to clarify further, in our own minds as well as in those of others, some of the ideas surrounding this subject.

I believe that most of us will agree that the ultimate aim of all our fishery work is to obtain the maximum continuous yield (optimum yield) from our fishery resources in the way of food, value, recreation or other return, for the benefit of our country, our state, our people, and our fishing industry (fishermen, dealers, etc.). Tonight we are concerned with a single, but vital element of this fishery program: What is the best way to go about the formulation and application of practical and efficient management measures designed to make possible these objectives. By itself, this is a complex economic and social problem. Perhaps our approach to it will be clarified if we can gain the proper perspective; that is, see how this particular problem fits into the complete picture of fishery management. Consequently, as a preliminary to the later discussion, I shall attempt to outline the primary elements or steps in a complete program. As the basis for such a program it must be assumed that it is known or believed that the fishery is not yielding its maximum. Some factor or factors is or are limiting the yield.

APPRAISAL OF THE MANAGEMENT PROBLEM

The first step is to diagnose the situation and determine in quantitative terms what factors are limiting production. Frequently history, properly interpreted, will provide a clue. Take, for instance, the overall problem of improving the fisheries of the Maine coast. What caused the decline in Maine's fisheries from 1888 to 1938? Was it due to biological, economic or technological factors? The answer to these questions will help to provide the basis for a rational approach to the present Maine problem. The United States cod fishery provides another example. What caused the decline in this fishery between 1880 and 1935 and how great was the decline? Answer that and you have your principal overall cod production problem. The United States mackerel catch declined from an annual average of about 100,000,000 pounds from 1860-85 to about 20,000,000 pounds from 1888-1923, and about 40,000,000 since 1925. Was this due to changes in the fleet, in fishing methods, in abundance of fish, or to changes in the fish's habits which made them less available to the fisherman's gear? The answers to these questions by themselves are involved and difficult, and an attempt to prescribe a remedy before the questions are answered, might at best be useless and at worst be dangerous.

Assuming that these questions have been answered to the effect that the limiting factor is the quantity of fish available, rather than economic or technological conditions, our second step is to determine what is controlling this quantity. If the stock of fish is reduced, is it due to unfavorable environmental conditions such as temperatures, feeding conditions, unfavorable ocean currents causing loss of eggs or larvae; or to the acts of man in catching too many fish, too young fish, changing the biological balance, or affecting the environment through use of destructive gear, dams, or pollution? How does so-called "destructive" gear such as the otter trawl affect the fish populations? Does it affect the bottom, spawn and larvae, young fish, or through efficiency of operation does it critically reduce

the spawning stock?

When we have discovered what conditions are limiting the stocks of fish, the third step is to determine how these conditions can be altered in order to permit the stocks to recover to the level at which they will provide the optimum yield. What are the conditions necessary to obtain the optimum yield? In general, the most important are an optimum adult stock and a fishery that takes the fish when they have reached the optimum size. (The optimum size involves the balance between growth and natural death). Other conditions that may be critical in some cases are predators, supplies of food, competition, physical conditions, etc.

In no case will it be found that return to virgin conditions of abundance and age composition is the answer, while in some instances the reduced yield may be the best that can be expected.

Once some of the above questions can be answered, it is possible to consider intelligently the application of management measures. Much of the failure of management measures during past years is due to the lack of this basic information. Their failure does not mean, necessarily, that the measures themselves were unsound basically, it means that without the essential knowledge of the ills to be corrected, the correct measures could not be prescribed. In the same way a surgeon might perform a highly proficient tonsilectomy which was prescribed to cure your rheumatism, but if the rheumatism were caused by infected teeth, the net result on your ailment would be nil. This does not prove that tonsilectomies are valueless; it simply proves the prescription was wrong.

It is possible to point out many examples in fishery administration, of prescriptions based on insufficient, erroneous, or completely lacking diagnosis. For instance, following the mackerel decline in 1885 and later, Congress passed an act prohibiting the landing of all mackerel caught between March 1 and June 1, except that caught by hook and line, traps, and weirs. This was in effect from 1888-92. It was a move in the dark and had no measurable effect in increasing the mackerel population. Failure simply meant that it was not the cure for that particular ailment, although it might be for another. The history of the lobster fishery records a long series of protective regulations, despite which the population of lobsters continued to decline. Most of these regulations were based on limited scientific facts or on personal opinion and, as the catch declined, pressure was increased to relax regulations. Personal opinion and limited facts were not sufficient bulwarks to prevent such action and regulations were relaxed progressively. So again, the methods were not necessarily wrong but lacking a fixed background of fact, it was not possible to devise adequate measures and defend them with sufficient determination and effectiveness. This might compare with the case of an individual who is dying from diabetes. The doctor believes that insulin will help, but lacking knowledge of how much is needed, prescribes an amount which slows down the approach of death but does not prevent it.

These examples might be continued at length and in most cases where protective measures failed, the failure was the effect of erroneous diagnosis or inadequate prescription. If we had adequate factual information from

scientific research, showing quantitatively the conditions needed in the way of fish sizes, spawning stock magnitudes, or other conditions required for the optimum catch, it would be possible to make the diagnosis more accurate and the writing of an adequate prescription would be simplified. To attempt to prescribe before accurate diagnosis is to revert to the level of medical practice in the Dark Ages. An exception to this should be made to cover cases in which fishery restrictions are used to alter conditions for experimental purposes, but this is not a prescription if used in this way and the purpose of such restrictions should be understood clearly.

This brings us to the fourth step in developing a management program, the formulation of effective, practical and adequate measures which will produce the conditions found to be necessary to permit the optimum yield. First of all, what are the technically ideal methods: that is, what methods theoretically are most effective and efficient? Second, what modifications, if any, are necessary to make the ideal methods economically and socially practical, and can these modifications be made without depriving the methods of their effectiveness? For instance, it might be proved that the optimum size for taking lobsters was 3-3/4 inches.3/ However, if there were a very limited market for lobsters above 3-1/2 inches, the practical economic level to be considered as a minimum would be 3-1/2 inches instead of 3-3/4 inches. This economic limit of 3-1/2 inches could be applied in a single increase from 3-1/8 inches to 3-1/2 inches, but that would not be socially practical since it would reduce the catch so seriously during the first one or two years that large numbers of fishermen and dealers would not be able to survive. Consequently, a reconciliation of biological, economic, and social requirements might result in a program involving a series of one-sixteenth inch or one-eighth inch increases at one- or two-year intervals until the 3-1/2-inch size was reached. This would provide the best practical conditions in respect to size. Other measures might be necessary if further protection were needed to maintain the most productive spawning stock.

FORMULATION OF MANAGEMENT MEASURES

To simplify and limit the discussion, it will be assumed that the primary purpose of the desired measures is to establish or permit a fishery which will produce the optimum yield from a given stock of fish, for our primary object is conservation. Improved economic and social conditions would be very important, but secondary, objectives. If you wish to reverse this order of importance, then the problem primarily is for the economist or sociologist instead of the aquatic biologist or conservationist.

In order to take up the next step in this program it will be assumed that the data required for steps 1 - 3 have been obtained and they show that: 1. The limited production from a given stock of fish is due to reduced catches. 2. The reduced catches are due to the decreased production of young resulting from an overfished spawning stock and from catching most of the fish while they are much below their optimum size (size at which natural death balances growth). 3. That the conditions necessary to

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3/ Carapace measure.

provide the optimum yield require an adult stock double the present level of abundance and an average fish size of three pounds compared to the present average of one to two pounds. Our problem is to formulate measures which will change the fishery in such a way as to obtain these conditions. This is a relatively ideal situation in which all of the needed biological answers are available before it is necessary to take regulatory action.

To Obtain the Optimum Size

In situations where unnecessarily small fish are being taken, the use of minimum size limits perhaps offers greater possibilities than any other measure. Protection in this way results in the small fish reaching a more productive size, thus increasing the yield in pounds from the same numbers of young fish. The protection of young also permits the survival to spawning size of increased numbers of fish, and this will help to correct any overfished condition of the spawning stock. This latter effect may be much more important than the first. Even when no overfishing is taking place, protection of the young may be worth while in situations where undersized fish (those below the optimum size) are taken, since it will result in a greater abundance (in pounds) and therefore in a higher yield per unit of effort. However, if the fishing intensity is low there may be exceptions to this generalization, particularly in cases where an overabundance of adults inhibits the production or survival of young. (Figures 1 and 2)

For the purpose of obtaining the optimum yield, the ideal size at which to harvest any group of fish is when the annual growth rate has slowed down until it equals the rate of natural mortality (optimum size). However, since normally it is impossible to determine this size exactly for all the individuals of a given population, and furthermore, since it is impossible to capture all of the desired proportion of the stock at any given size, the practical size limit must deviate considerably from the ideal. In cases where the fishing intensity is low and the natural death rate high, the most productive size limit will be considerably below the optimum size. This will enable the fishery to catch a considerable proportion of the stock before it is seriously reduced by natural death. On the other hand, if the fishing intensity is high or the natural death rate low, the most productive size limit will be but little less than the optimum size. Conditions intermediate between those cited will require some intermediate size limit. Thus, the position of the theoretically most productive size limit will vary for different species and even for different populations of the same species, depending on the interrelationship between fishing intensity, growth, and natural death.

The effective use of size limits depends on a number of characteristics of the species and of the fishing gear used. If the species is sufficiently rugged so that it can be caught, sorted, and released without considerable losses through mortality, then a size limit can be readily applied. Most of the flounders and many fresh-water fish are in this category.

For a species which cannot survive handling in this way, some form of savings gear may be effective. This gear must allow the release of the fish at such a time and in such a condition that most will survive. Satisfactory forms of savings gear have been developed for haddock, cod, flatfish, possibly lobsters, and many other species. This method is desirable even

for species that can stand catching and sorting, since it reduces the hand labor and removes the temptation to keep the small fish. The chief disadvantage of such gear is that it is not precise in its cull: that is, a gear which retains all fish above a specified size, also will capture considerable numbers of fish just below this size. Consequently, allowance must be made for this characteristic, both in the savings gear specifications and in enforcing the minimum size limit.

Some species fall into a third category which includes those which neither can survive catching and sorting, nor can they be culled effectively by types of savings gear now available. This group may include the rosefish Sebastes marinus, the mackerels, herrings, and others. To use size limits successfully for these species it will be necessary to develop other types of savings gear, or to protect the small fish through closed seasons, closed fishing grounds, or by the use of other measures.

For most fisheries there appears to be no sound argument, biological, economic or social, against size limitation, except possibly that referring to the hypothetical genetic effect of size selection on the size of fish in future generations. There also may be exceptions for economic reasons, such as those involved in the case of sardine herring. If practical and effective methods of size limitation can be devised, this should be one of the first tools to be considered by those planning management measures.

To Obtain the Optimum Adult Stock

For the present, let us assume that before considering this question the administrator has been supplied with information showing that the current spawning stock is considerably below the ideal size, and that the reduction was due principally to overfishing. What is the best method for obtaining the conditions needed to build up and maintain the ideal stock?

The size of the spawning stock is affected by numerous environmental factors including the fishery, fish food, natural enemies, and others, but in a marine fishery the first-named usually is the only one that can be altered appreciably by man. Assuming that the best practical size limit is in use and has not provided sufficient protection to enable the spawning

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FIGURE 1.--The effect of size limits on the catch and spawning stock, using data on growth rate, natural mortality, and size at maturity, from the haddock fishery, and assuming an addition to the stock each year of 1,000 quarter-pound fish. The upper figure shows the pounds of fish of each size that would be taken with the various size limits in force.

In the lower figure, the area below the curves represents the number of fish of each size left on the banks under various size limits. The dotted curve represents the stock when there is no fishery. The total shaded area represents the number of mature fish left with a four-pound size limit in effect; the total of medium shaded and black area represents the mature stock left with a two-pound size limit in effect; and the black area represents the mature stock left with a one-half-pound size limit.

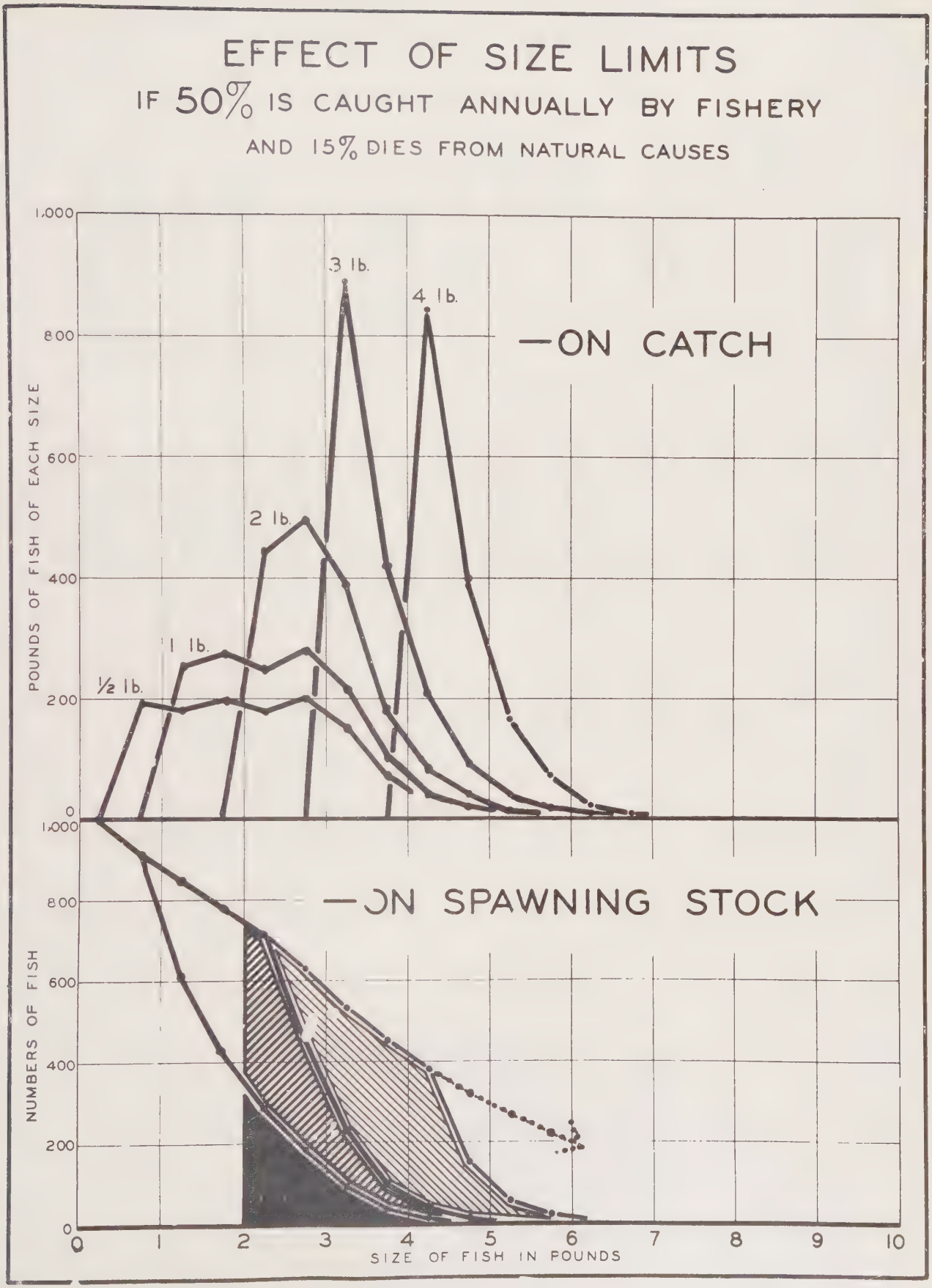
EFFECT OF SIZE LIMITS
IF 50% IS CAUGHT ANNUALLY BY FISHERY
AND 15% DIES FROM NATURAL CAUSES
—ON CATCH
POUNDS OF FISH OF EACH SIZE
1,000
800
600
400
200
0
3 lb.
4 lb.
2 lb.
1 lb.
½ lb.
—ON SPAWNING STOCK
NUMBERS OF FISH
1,000
800
600
400
200
0
0
1
2
3
4
5
6
7
8
9
10
SIZE OF FISH IN POUNDS

Figure 1

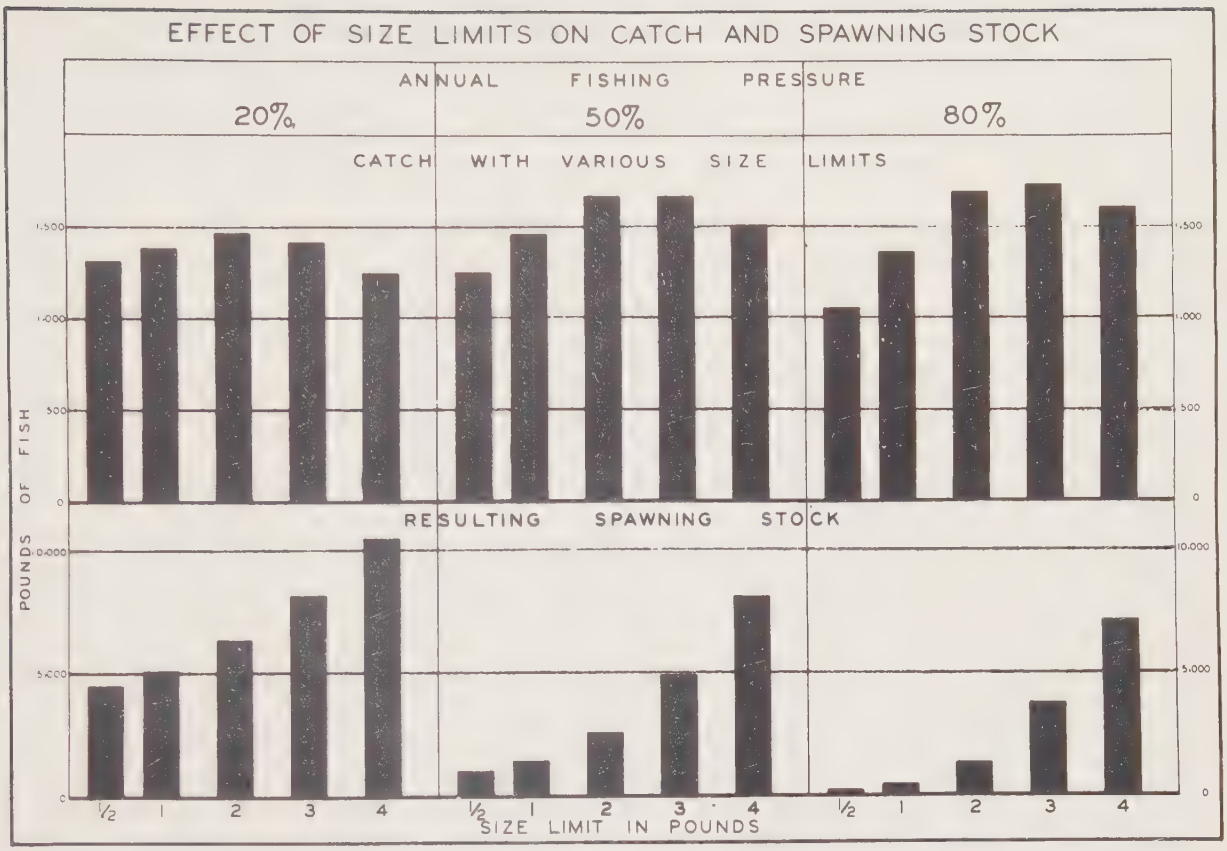

Figure 2

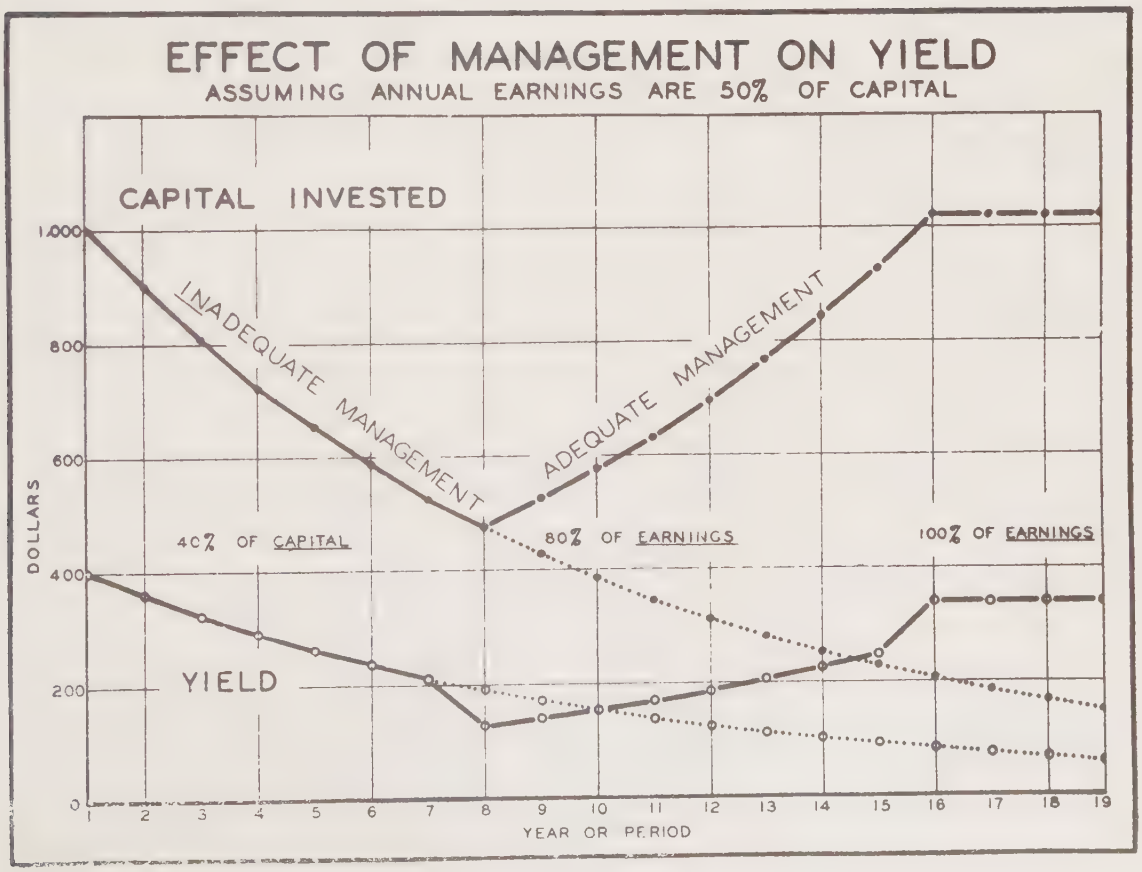

Figure 3

stock to reach the optimum level, the next thing to consider is the fishing intensity. The spawning stock is too small because too many fish are being destroyed by catching or other operations conducted by man. Assuming the destruction is due to fishing operations, how shall this be remedied?

A considerable variety of restrictive methods for reducing fishing intensity are available to the administrator. The ultimate purpose of all is to limit the catch to the amount which will permit the maintenance of the optimum spawning stock. Probably the most important of these methods are the following:

Direct Catch Limitations

Direct catch limitations might involve the establishment of annual or seasonal quotas for given areas. When the quotas were filled, fishing would be halted. The most drastic application of this method would require the complete stoppage of fishing (zero quota) until the stock had been restored to the desired level. Since the most rapid recovery of the spawning stock usually can be obtained by using zero quotas, this method is used in many cases to restore wild populations depleted by sportsmen or by natural catastrophies. In the case of commercial species, however, there are numerous economic and social reasons for avoiding such drastic action. These include the effect on the livelihood of the fishermen and the danger of causing manpower and equipment to change over to other fisheries or occupations. In the latter event, inadequate fishing capacity would be available to make use of the increased supply of fish when fishing was resumed. Sportsmen can give up duck shooting for several years when such hunting is closed, then return to it in equal or greater numbers than ever when open seasons are resumed; but a commercial fisherman must starve or turn to some other occupation if fishing is stopped. There also are certain biological reasons which indicate that complete cessation of fishing is not the most efficient method to build up the adult population.

Because of the undesirable effects of zero quotas, which have been referred to above, in the commercial fisheries, it is better to use reduced, rather than zero, quotas when such limitations are necessary. The extent to which they should be reduced will depend on the situation; in general, the smaller the reduction the longer it will take to build up the stock to the desired level. Usually it will be possible to increase the quotas somewhat after a rather short period, since with an increased spawning stock, the recuperative powers of the population are increased. Consequently, it may not be necessary to reduce the catch below the prerestricted level for more than a brief period. (Figure 3, opposite p. 10)

The advantages from using the method of direct catch limits are numerous. It is the most direct, precise, flexible, and effective method available. When the catch is too great by any given amount, it can be reduced by that amount. Changes can be made from year to year if they are found to be necessary. The experience of the International Fisheries Commission demonstrates that enforcement is practicable.

The chief disadvantage is that if the permissible quota is filled before the normal fishing season is over, fishing for this species nevertheless must cease. Men and gear then must shift to some other fishery or occupation

FIGURE 2.--The effect of size limits on the catch and spawning stock. The data shown under 50 percent fishing pressure, are summaries of the weights shown in Figure 1 for each size limit. Data for 20 percent and 80 percent fishing pressures were calculated in a like manner. Note the considerable effect of size limits on the catch when the fishing pressure is high and the tremendous effect on the spawning stock.

This is a simplified picture based on the assumption that the annual production of young fish is constant (1,000 quarter-pound fish). Thus, as shown in this figure, the increased catch with intermediate size limits results entirely from concentrating the fishery on fish near the optimum size. In the case of the haddock fishery at least, we know that the production of young is closely related to the size of the adult stock. Consequently, the increase in the spawning stock resulting from size limits would have a much greater effect on the catch than that represented in Figure 2, which is the result solely of concentrating the fishery on the best sizes. At the lower levels of spawning stock magnitudes, the increased stock resulting from higher size limits would result in a greatly increased production of young; while at the higher levels, any increase in spawning stock would be harmful since it would decrease the survival of young. Thus in fisheries of medium and high intensity, the actual increases in catch derived from intermediate size limits are much greater than are indicated in this example.

FIGURE 3.--The effect of management measures on yield as illustrated by investment and earnings. This example assumes a private business with an original capital of $1,000 and annual earnings of 50 percent on the investment, with the withdrawals (yield) taken out the first of each year. Under inadequate management, when 40 percent of the capital was withdrawn annually (years 1-7), there was a continued decline in capital and yield. Under adequate management, which restricted yield at first to 80 percent and later to 100 percent of earnings (years 8-19), capital was rebuilt and the increasing yield in three years (years 8-10) was equal to what the decreasing yield would have been under inadequate management; thereafter it was increasingly greater.

This example represents essentially what occurs in an overfished fishery when the catch, which at first is greater than the annual increase in the stock, is brought into balance by properly planned management measures. However, the fishery problem is considerably more complex than this, due to natural mortality (death from natural causes), migrations, variations in production of young, and other factors.

for the balance of the year or remain idle. If the gear remains idle, it creates technological inefficiency which is undesirable. If men remain idle, it creates a more extended vacation, which is good or bad depending on your point of view concerning the value of time for recreation and mind improvement. If the combined effect is such as to hold the returns on time and investment to levels unattractive in relation to other occupations in that region, it will result in a gradual transfer of money and manpower to other occupations, until the balance is reestablished.

Other undesirable effects of the stoppage of fishing when quotas are filled, are the loss of supplies of fresh fish to the public and a protracted period of unemployment for the shore workers. Effects of the former are reduced by the increased use of frozen fish and cold storage, while effects of the latter might be reduced by staggered opening dates for different areas, or by other arrangements.

Indirect Catch Restrictions

The purpose of nearly all other types of restrictions on fishing, if considered from the point of view of conservation, reduces to the same basic purpose as direct catch limitations. Closed seasons, closed areas, and restrictions on gear and number of fishermen, all are methods for reducing the number or pounds of fish taken. Even minimum size limits can be considered from this point of view, since the first effect from protecting the smaller sizes is to reduce to some extent the number of fish taken.

Closed seasons.--This method has most of the disadvantages of direct catch limitations and few of the advantages. Probably the only argument in its favor is that it is easy to enforce. It is not precise, since the effectiveness of a reduction of 20 percent in the season's length, in an effort to obtain a 20 percent reduction in the catch, would depend on the time of the year included and might easily be rendered ineffective if the fishermen worked a little harder during the open season. Results also would vary if conditions were particularly favorable or unfavorable for good fishing, or if improved fishing methods were devised. The method is reasonably flexible, since the length of the closed period might be increased or decreased to any extent necessary. If it were varied according to total catch landed, then it becomes essentially a catch limitation rather than a closed season. The effect on shore workers and consumers would be similar to that from catch limitations.

The chief virtue of this method is that it can be enforced with a minimum of data. When the season ends, fishing stops regardless of the quantity of fish caught. Thus, it would not be necessary to obtain current records of landings. However, since reasonably current data on landings would be needed for any adequate management program, this saving would be largely fictitious.

Closed seasons frequently are used to protect the fish during the spawning season. Closure during this period is somewhat more beneficial than closure during equivalent portions of other seasons, but the benefits are not nearly as great as generally is believed. Capture of 1,000,000 pounds of butterfish 6 months before the spawning season kills nearly as many eggs as does the capture of the same number of fish just before they

spawn. However, there are some advantages to protection during spawning. First of all, 1,000,000 spawning fish represent a little higher egg potential than do 1,000,000 fish 6 months earlier, for the latter group will lose some of its number through mortality. The second and probably most important argument for protection during and just following spawning, is that during this period the fish are in poorest condition. Thus, if the effect of spawning reduced the average weight of the fish by 25 percent, a population of adult fish weighing 100,000,000 pounds before spawning would be reduced to 75,000,000 pounds during and just following the spawning season. The weight of the population would then recover toward 100,000,000 pounds again during the following months. Consequently, the potential yield from this population will be greater if no fishing is carried on during this season of poor condition, for a given number of fish will yield one-third more pounds of fish after they have recovered their weight than they will during this season. The amount to be gained in this way will vary for different species. In the case of haddock it would be small, since the gain in average weight between the spawning season and the summer is only 10 to 15 percent. In the case of mussels it would be large, for the average weight of the meats will more than double between the summer and winter seasons.

When used for the purpose last discussed, the closed spawning season is somewhat similar in its effect to the minimum size limit: fish of low individual weight are protected until they gain in weight and thus permit a greater yield.

It appears from these data that if a closed season is to be used to limit the catch, the best time to apply it is during and following the spawning season. However, this measure by itself usually is not effective in limiting the catch to any desired level, since there is a strong tendency to compensate for the reduced fishing time by increasing the fishing intensity during the open season. Consequently, the closed season usually should be considered a secondary management measure to be used only in special circumstances or in conjunction with other measures.

Closed areas.--Closed areas usually are used either to protect fish during some specific stage in their biological development or to provide a sanctuary for the species. In the first case, the area might include the nursery grounds where the young are concentrated, or it might cover spawning areas. Thus, in the first example, the closed area is used as a substitute for size limits to protect the young, and in the second, as a substitute for a closed spawning season to protect the spawning adults. In neither case is it as precise a measure as the one for which it substitutes, for with marine species it usually will not be found that segregation by size or maturity will be sufficiently clear cut to permit selection of an area that will include only those fish which it is desired to protect. Most anadromous fish are exceptions to this generalization, since they leave the river before reaching their full size.

Use of closed areas as sanctuaries is based on the argument that by providing grounds where the fish will be able to reproduce and grow without molestation from man, they will multiply and spread out to restock the heavily-fished areas. This method usually is inefficient, since it generally results in the overstocking of the sanctuary areas and the understocking of the unprotected areas. In neither case does this provide for the most

effective use of the natural food supply.

Closed areas used to protect small fish, spawning fish, or as sanctuaries usually will not provide a precise instrument for maintaining the spawning stock at any desired level or for providing protection for fish below a given size. From the point of view of precision, it is one of the poorest methods available.

Closed areas may be flexible in their dimensions, but the dimensions probably would have no simple relationship to the effect on the fish population. Consequently, the flexibility could not be used effectively in a management program.

Facility with which closed areas can be enforced will depend to a large extent upon their location. In inshore areas they can be defined and observed with some facility and enforcement would not be difficult provided sufficient inspectors and patrol boats were available. On the offshore banks the areas might be defined precisely in latitude and longitude, but their boundaries would be difficult to observe, particularly in overcast and foggy weather. If such areas were large or numerous, enforcement would require a considerable patrol fleet.

In view of the limited advantages and numerous disadvantages of closed areas as a method for management, it is obvious that they should be resorted to only when more effective measures will not function or for special cases in which some peculiarity of the fish or fishery makes them suitable.

Restrictions on gear.--This type of restriction may take the form of a limitation on the amount of gear that can be used by a single fisherman or on the type of gear that can be used. Restriction of the total amount of gear that can be used in a fishery would amount to restrictions on the number of fishermen if there were a limit on the proportion of the total which could be fished by one man.

Restrictions on the amount of gear that can be used might consist of limits on the number of lobster pots, length of seine, or size of otter trawl. In general, this amounts to telling a man how hard he can work (number of lobster pots) or how efficient equipment he can use (number of plows a farmer can use in a gang plow, width of his hay rake, etc.). To the extent that we believe that it is advantageous to the State and Nation to have industrious citizens and to make use of efficient machinery for production, we must agree that in general such restrictions on gear are undesirable.

Restrictions on the type of gear that can be used might consist of prohibiting the use of otter trawls or certain types of otter trawls, or barring the use of explosives, line trawls, etc.

Considered from the point of view of limiting the catch, restrictions on gear usually are neither efficient, precise, nor flexible, and their occasional ease of enforcement does not compensate for their numerous weaknesses. However, they may be very desirable for special purposes: for instance, gear that is unduly destructive to the fish, to fish food, or to the fish's environment, is undesirable even though it may be very

efficient technically. On the other hand, it appears to be highly fallacious to bar a type of gear because it is too efficient. An example of the first type might be dynamite, one of the last type would be the barring of line trawling in favor of hand lining. Otter trawls provide an intermediate example. As usually used, they are destructive of small fish, but if this effect is corrected, the chief basic charge that can be proved against them is that they are efficient. If the destructive characteristics cannot be remedied, then there is a valid charge against this gear on the grounds of conservation, but any charge based on the grounds of efficiency must look to debatable social arguments rather than to biological. In some cases, even though a gear is incurably destructive, its use may be justified if no other practical gear is available, for if its use were barred, the fishery would disappear.

Regulation requiring the use of savings gear is a form of restriction when it requires some change from the gear normally used. Since it is used to convert a destructive type of gear into a non-destructive type, it is a desirable conservation measure. Used for protecting certain sizes of fish, it may be a reasonably efficient, precise, and flexible measure (mesh sizes, slat spacing in lobster pots), but if used for limiting the quantity of fish taken, it possesses these characteristics to a much lower degree. Usually it can be enforced with reasonable facility. In those cases where the best savings gear available is inefficient, unprecise, and difficult or expensive to apply, its use may be impractical and therefore undesirable, even though it might to some extent reduce the destructive effect of the gear to which it was applied.

Restriction on the number of fishermen.--As generally applied, this method requires that all fishermen be licensed and that the number of licenses issued be limited to some predetermined number. For conservation purposes the number issued would be based on the results of studies showing how large a catch should be taken from a given population of fish and the average catch per fisherman. If the fishermen should increase their efficiency or improve fishing methods by developing better gear or boats, then the number of licenses would be decreased until the total catch again was reduced to the desired level.

In general fishermen can vary their catch over a rather wide range. For instance, the lobster fisherman may fish any number of pots from a few up to several hundred, and he may fish one month or twelve. Furthermore, the number of pots that can be handled by one man will vary from place to place, for the maximum number of pots that can be taken care of under certain conditions will be only a fraction of what is possible under others. The catch taken by a salmon trap will depend on the length of the leader as well as the location of the trap. The catch of a purse seine will depend on its size; that of an otter trawl upon the towing speed of the boat as well as the size of the net. Consequently, to have any degree of precision in limiting the catch, restrictions on the number of fishermen must be accompanied by restrictions on gear. Thus, the number of lobster fishermen would be fixed as well as the number of pots per fisherman. In the haddock fishery, it would be necessary to specify the number of fishermen and boats, the size, power and equipment of the boats, and the kind and size of net.

If this method were used as described, it would provide a reasonably effective, precise, and flexible instrument for controlling the catch and it would be relatively easy to enforce. The chief lack of efficiency would occur in fisheries where the fishermen could vary their individual effort over a considerable range. For instance, in the lobster fishery a limit of 100 traps per man might be allowed. Under some conditions a man normally might be able to handle 200 traps, so under this restriction he would be forced to work at 50 percent capacity. Furthermore, in years when lobster prices were very low or the attractions of other work high, the average fisherman might reduce the number of traps he fished, or months he operated, sufficiently to lower the catch 25 percent or more below the desired level and no one else would be able to make up the difference. In fact, it is not unheard of to have certain combines reduce production in order to increase prices. In this event, the public would be deprived of quantities of foodstuffs; possibly needy fishermen would be deprived of the opportunity to capture a permissible quantity of fish; and the surplus left on the fishing grounds might inhibit survival of young so as to reduce the production of fish for several years thereafter. If adjustment were made for the reduced catch during one year by issuing additional licenses the next, and at the same time, part-time fishermen returned to full-time fishing, then the catch would jump far beyond the desired level. These variations would take place even though both men and gear were restricted.

Discussion of Relative Merits of Various Methods

From the point of view of conservation, the best methods of management are those which are most effective, precise, flexible, and enforceable. On this basis, the methods which have been discussed rate somewhat as follows:

Minimum size limits, where they can be applied, have many advantages and few disadvantages. Consequently, this method rates as one of the best at the disposal of the conservationist. This seems to be so obvious that no further discussion is needed.

For the purpose of holding the catch at the level which will provide for the optimum adult stock (this catch may vary somewhat from year to year), a number of methods are available. Judged by the standards previously stated, the most satisfactory method in most cases is the actual limit on the catch. All other methods are indirect attempts at the same objective. Closed areas and closed seasons are useful for certain special situations but provide no overall substitute for actual limitation on the catch. Restrictions on men and gear provide a general substitute for catch limits, but involve complications and inefficiencies which make them technically less satisfactory for general use. However, they may provide the best solution for special cases such as fixed trap and net fisheries, where fixed locations can be occupied and one net can blanket another.

THE RESTRICTED LICENSING PLAN

Applications to Management Program

In view of the fact that restricted licensing has been proposed for adoption by this Commission as a basic management policy, I shall undertake a somewhat more detailed exposition of its application to a management

program by attempting to see how it would work out in a boat fishery.

Let us assume that we have a population of fish in which the spawning stock has been reduced by overfishing or other conditions, until it is not large enough to produce the number of young needed to utilize fully the available food and nursery grounds. Let us further assume that the commercial fishery is taking such a large proportion of the fish that the spawning stock is not increasing, but in fact, is decreasing further. It is desired to apply management measures which will build up the stock and provide for the maximum continuous yield. Restricted licensing will be used as the basic management method.

It is first decided to license all boats and fishermen. However, since this is a boat fishery and adequate crews must be available to operate whatever boats are permitted, it is decided to drop the licensing of fishermen and license the boat only. This still leaves a variable fishing effort, for the number of men on a given boat may change and this will affect the catch to some extent, but there appears to be no satisfactory way to stabilize this variable. To attempt to specify the number of men per boat does not seem to be practical, for the sizes and types of boats differ too greatly. Furthermore, fixing the size of crew would freeze the number of men and restrict the development of more efficient fishing methods or boat types which required fewer men. The law-making authority would be telling the captain or owner how many men he must use on every size and type of boat.

In order to make the necessary temporary reduction in the fish catch, it is decided to reduce the number of boats by 20 percent. Since most of the boats are owned by corporations, the plan of reduction by mortality of owner or lapsing of license would not be practical, so it is decided to draw lots totaling 80 percent of the number of boats in operation in this fishery on some base date. Operation in the fishery would be defined as covering all boats whose catches during the base year included 50 percent or more of the species to be managed. The 20 percent of the boats not receiving licenses could shift to some other fishery, or if other fisheries were restricted similarly, would go out of business. The crews of the boats also would be forced out of the fishery when the owner lost his license. Distribution of licenses by sale to the highest bidder could be used as an alternative method. Under this system, the value of a license to the owner would depend on the size or type of his boat so the big boat operators or outside investors probably would get all the licenses and the final set-up would be somewhat like the New York Stock Exchange.

Since the number of boats, not the size, would be limited, the owners of small boats immediately would undertake to obtain larger boats in order to obtain a larger share in the reduced total catch. This trend to larger boats would cause the catch to increase again so that there must be a further reduction in the number of boats. Thus, the fishery probably would end up with large boats only, not because the large boat yields the individual fisherman more money or is a more efficient producing unit, but because the gross take is greater. For instance; a $50,000 boat catching 1,000,000 pounds of fish worth $50,000, might yield the owner $10,000 net, a return of 20 percent on the investment; while a $250,000 boat catching 4,000,000 pounds worth $200,000, might yield $25,000 net, a return of 10 percent. Thus,

although the smaller boat was a more efficient fishing apparatus in proportion to its cost, it yielded the owner $15,000 less income. If you could operate but one boat, which one would you choose, even though you found it necessary to find help to finance the more expensive boat?

With each increase in the size or catching capacity of the boats, a further reduction in number would be necessary. If the reduction were by lot, the number reduced would depend on the size of the boats the revoked licenses covered. In any event, loss of a license would result in hardship for the crews, who would be forced to look to some other occupation, and to the boat owner who would find his property of little value when it could not be used for fishing. The owner might be helped by receiving a sum from the licensing agency to repay him for his investment, but how would you repay the fishermen for loss of their trade? It seems probable that to avoid the complications that thus would result from increases in the size and capacity of the boats, the licensing agency would decide to license a fixed number of boats of each type, the licenses to be proportional to the number operating on the base date. Such a system effectively would freeze fishing techniques and prevent further improvements in gear and methods. Under such a system, what would have been the probability of approving otter trawlers in 1905 or Vigneron Dahl gear in 1927?

After several years, if the program were successful in building up the stock of fish, it would be necessary to license additional boats to make use of this additional stock. How should this be done? If by lot, the new licenses might go to men entirely inexperienced in fishing, while experienced fishermen were left on the beach. If auctioned to the highest bidder, the small boat owner would have little chance to get a license. Furthermore, the prospective purchaser would need some assurance that he would not soon be deprived of his license, by lot or otherwise, or he could not afford any considerable investment in boat or gear. If the license period extended for a long term of years to provide the needed investment security, this management method would lose its flexibility for holding the fish population at the most productive level, since it would not be possible to vary the effort from year to year to take care of changes in the stock due to factors other than the commercial catch. This would interfere seriously with effective management of the stock.

Controlling the catch by restricted licensing becomes complicated further if the fish populations in different areas must be managed separately. If the fishery in these areas were seasonal, then the boats must be licensed to fish several areas in order to operate continuously. When such a choice of fishing grounds is available, it is not probable that the desired catch would be taken from each area. Consequently, a quota system would have to be superimposed upon the licensing system, in order to obtain effective management.

For instance, the proper catch of a certain species might be 30,000,000 pounds from Browns Bank, 30,000,000 pounds from South Channel, and 10,000,000 pounds from Jeffries Bank. It is caluclated that it will take 35 boats to make this catch, so this number is licensed. However, since South Channel is much closer to the home ports, the boats concentrate there and take 50,000,000 pounds compared to 20,000,000 on Browns and 5,000,000 from

Jeffries. This results in South Channel being overfished and its future productivity reduced, while the other two banks are underfished. To stabilize these variables sufficiently to permit effective management and maintenance of the South Channel fishery, area quotas would be required.

In order to obtain an effective and practical management program using restricted licensing as the basic control method, it would be necessary to add restrictions on gear, which would decrease the efficiency of operation and restrict the development of more efficient fishing methods. It also would be necessary to use a quota system for the different areas, and if destruction of small fish were involved, to use size limits to protect the young. Thus, to the basic method with which we started, must be added other methods which by themselves are more effective in providing the fishing control needed. Consequently, it seems clear that restricted licensing would not be needed for conservation purposes. Its use as the basic method must be justified on arguments other than conservation.

Social and Economic Considerations

It already has been shown that when it is necessary to control the amount of fish taken in order to maintain the stock at the most productive level, direct catch limitation usually provides the most effective, flexible, and precise method. Therefore, to justify using for this purpose any other method, such as restrictions on number of fishermen or boats, we must look to special conditions or rely on social and economic arguments. One of the principal of such arguments for restricted licensing is the claim that it will increase the fisherman's income.

In considering this, first of all it must be decided whether restricted licensing is to be used to attempt to increase the fisherman's income in all cases where this income is below the level to which he is entitled, or only in those cases in which research shows the need for a controlled catch in order to maintain or increase the yield. In either case, we immediately are faced with the problem of determining the income to which a fisherman (also the owner) is entitled. Furthermore, is it the same for all kinds of fishing and for all parts of the country? If not, what are the proper differentials among various fisheries in which the men return home each night, those which involve absences of two to four weeks, the various Alaskan fisheries, southern fisheries, and so on? In cases where an increase in income is the only objective, it must also be determined how far we are justified in limiting yield and employment in order to obtain these debatable income levels for the licensed fishermen.

For instance, under normal conditions the United States catch of cod has been limited only by the market (price). Let us assume a prevailing price of 2-1/2 cents a pound which yielded the fishermen shares averaging $100 a month. It is decided that this is too low, so the number of boats fishing for cod is reduced. This reduces the catch and presumably should result in an increased price. The higher price reduces the market and with the lessened demand, the price again may drop toward the original level; then the whole cycle must be repeated. Thus, we have reversed the usual economic cycle that serves to increase the catch. Instead of letting the abundant supply lead to a low price which would stimulate demand and lead

to better prices, we have increased prices which reduced the demand, and so on. On the surface it would seem that restricted licensing generally should not be used in cases where the only question involved is that of increased income.

We shall assume that it is intended to use restricted licensing only in cases where management is needed to maintain the yield. What are its advantages when used for this purpose?

First of all, the number of licenses is reduced according to some formula based on lottery, sale, or mortality of owner. For the time being we shall pass over the technical complications involved in developing an acceptable formula and assume that a satisfactory method for reducing licenses is available. The first result from applying the restrictions is to force large numbers of men and boats out of the restricted fisheries. These men either must seek some other occupation or enter fisheries which are not overexploited and therefore remain open. If they are forced into another occupation, they increase the competition for jobs in that industry, therefore, tend to lower the income level prevailing there; or, if the number of jobs is limited, to obtain work they must force others out of employment on relief. If they enter open fisheries where production is limited by the market demand, they increase the yield and this decreases prices, thus reducing the income of the fishermen previously engaged in this fishery. Thus, the first result of restricted licensing probably would be to reduce the income of other fishermen or workmen in order to try to boost that of a special group.

If the theory of restricted licensing works out properly, the next result from applying this method will be that in the protected fishery the remaining fishermen's individual catches and incomes will be increased. If, as is expected, this income becomes considerably greater than that for men in unprotected fisheries, an increasing pressure will develop to extend protection to all fisheries, regardless of their conservation requirements, in order to reduce competition and increase individual income. If this is done and the usual laws of economics hold, it will result in generally reduced catches and higher prices, thereby handicapping the further development of the fisheries in the manner that already has been discussed for cod.

Following the developments we have discussed, certain further steps are probable. Workmen in unprotected, low-income industries, which have been forced to take in the men squeezed out of fishing, will observe the seeming benefits derived from restricting competition in fishing. In all justice, they would be entitled to the same protection and presumably would get it eventually. The ultimate goal toward which this system leads, therefore, is an economic world in which restricted licensing will attempt to reduce the number of workmen in each industry until the average or minimum income rises to some satisfactory level. It would seem that this must have certain sure results. First, a considerable pool of men will be relegated to unemployment, a perpetual WPA, regardless of their desires or skill. To support them at a decent living standard, which must be the obligation of the economic system which has forced them into idleness, the working members must be taxed. Furthermore, the higher prices made necessary by the higher individual incomes (when they are obtained by virtue of reduced

competition and yield) must increase the living costs of all workmen. At the very least, it is debatable whether or not the higher income obtained from the protected jobs will offset these increased living costs and taxes. There also is the possibility that this restrictive method will start an ascending spiral of earning and living costs.

Let us pass over these tentative conclusions concerning long-time developments and return to the point where the licenses in a given fishery have been restricted. Presumably, the fisherman's individual share will increase presently. Since the licensing agency has assumed the social responsibility of deciding that the fisherman's income is too low and granted him a State- or Federal-protected monopoly in order to increase it, that agency also must take the responsibility for preventing him from earning too high an income in comparison with his unprotected fellow workers in other industries. Consequently, in addition to deciding the minimum amount to which a fisherman is entitled, the maximum amount also must be determined.

These two problems must lead to a multitude of complications. If by rule of thumb or otherwise, $5,000 is decided upon as the maximum, and the average income rises above this level, how will it be controlled? If by special confiscatory taxation, then a fisherman would have no incentive to continue working after his annual income reached the maximum level. This would result in inefficiency of manpower and boat use, and by decreasing his catch would throw the conservation program out of balance. If the increased income were reduced by licensing more men or boats to share in the catch (if this could be done in spite of the inevitable pressure groups), the fishing intensity would become too great, the catch would rise beyond the optimum level, overfishing would result, and again the management program would suffer. To prevent this it would be necessary to superimpose direct catch limitations upon restricted licensing.

Let us take another example in which the number of licensed fishermen has been adjusted to yield the desired income, and the fish population has increased until it can support a greater fishery. What should be done? If more licenses were issued, the desired catch increase would be obtained but prices would drop, thus providing the increased yield but decreasing the average income. On the other hand, if no more licenses were issued, the average income might be maintained, but the increased productivity of the fish population could not be used.

Another development which must be considered, will result when the price of fish changes considerably over a period of years. In this event, should the number of licenses be varied in an atempt to maintain the fisherman's income? There certainly will be pressure to do so. If the licenses are varied for this purpose, the program then is not one which will promote the maximum production of fish.

From these examples it seems obvious that any attempt to use the same management measures to obtain both the optimum yield and the optimum income, will lead to a confusion of issues and an inefficient management program. Measures will be justified on conservation grounds when their real purpose is to increase income. It is very probable that if the conservation issue is not submerged totally by the income issue, the final result of this program, which started out with restricted licensing, will require the

addition of catch limitations, gear limitations, size limits, and other measures. By that time the issue of conservation versus income may be so confused that each case will be determined by immediate superficial conditions rather than by basic principles.

AN ALTERNATIVE METHOD OF MANAGEMENT

In this discussion I have been attempting to evaluate some of the characteristics of various management measures in relation to the objectives of fishery management. Such measures also must be considered from the point of view of sociology and economics as well as conservation. I feel qualified to rate them on conservation grounds as I have, since that is my special field. On social and economic grounds I am less sure, since I cannot speak as an expert, and I can judge the social and economic effects only so far as I can anticipate the kind of world to which they will lead. Since there seems to be no sure rule to guide my selection of the better world, I have preferred to refrain from social and economic rating of the various management measures. I have attempted only to show, within the limits of my ability, the way in which certain measures will work out and the conditions to which they will lead. It is for you to decide whether such conditions are desirable or undesirable. In making this decision, possibly you will agree among yourselves to the extent that you can agree that the anticipated world I have sketched, or one of a somewhat similar kind, is a logical development of the type of managed economy which has been proposed.

I am well aware that in the long run human values are much more important than are the fish themselves. There is no point in preserving our fisheries unless we also preserve our fishermen to pursue them and enjoy the return from their efforts. Consequently, any program aimed to give the fisherman a fair return for his work should receive your most serious attention. In considering the merits of restricted licensing as an overall management measure, I have no doubt whatsoever concerning the desirability of its social objective so long as that objective is a fair deal for the fisherman. My principal question is whether in the long run the fisherman will be better or worse off as a result of the overall use of this method. I am also concerned as to whether use of the method would disrupt the general conservation program to the extent that the productivity of the fisheries would be reduced considerably.

Consequently, I wish to suggest the following course of procedure:

If this Commission wishes to pioneer a managed social economy in the fisheries, to attempt to insure to every man the income to which he is entitled, and at the same time insure the benefits of an effective conservation program, I believe the following general approach will be most effective, productive, and clear-cut: 1. For any given fishery that needed management, the requirements for the optimum catch would be met by application of size limits and some form of catch limits. This would insure the best utilization of the resource. 2. The requirements for minimum or average income would be met by application of measures restricting the number of fishermen, gear, fishing time, or other competitive unit.

By using this procedure, the administrator would make use of the most effective measure for obtaining each objective. Confusion of issues would

be eliminated and each program would stand or fall on its own merits. To attempt to accomplish both objectives by the use of restricted licensing is something like the case of a man who wished to cut a board and drive a nail. He could use a hammer to drive the nail and to break the board, or he could use a saw to cut the board and to drive the nail. However, he would do a much better job by using a saw to cut the board and a hammer to drive the nail. Why should he select one tool for the dual job if both tools would do a better job and were available? It seems better where possible, to use special tools for special jobs, catch limitations for conservation management, and restricted licensing for income management, if that is desired.

How this program might work out can be illustrated by the following example:

To prevent further decline in the Pacific halibut population and to build up the stock in order to obtain a higher yield, direct catch quotas were established after extended scientific study. The program was successful. The individual fisherman's catch increased, and the total catch increased, but this resulted in more men entering the fishery and catch quotas were filled in a shorter time. As a consequence, an earlier closing date was necessary and the returns per fisherman declined until they were more or less in balance with competitive industries. Thus, the management program resulted in a greater total catch, it provided more food for the nation, a livelihood for more fishermen, and more employment for shore workers. However, in the long run, the average income per fisherman increased only to the extent that more jobs and the increased yield, stimulated better employment conditions in the region as a whole.

Now, if it is decided that the fisherman is entitled to an income greater than this, the State or Federal Government could license the fishermen and experiment with reducing their number until the approved income were obtained; or the fishermen's organization could establish a closed shop and reduce membership until the individual earnings reached a satisfactory level. During years of low prices, the regulatory authority or the fishermen's union could decide whether it would be better for all fishermen to share the reduced income or to decrease the number of fishermen until those remaining enjoyed a satisfactory return, while those excluded could seek employment elsewhere or go on relief.

Under this plan, the optimum catch would be obtained by effective conservation measures and the pros and cons involved in developing a satisfactory program for income management would not jeopardize realization of a sound conservation program. Furthermore, the issues would not be confused and neither the fishermen nor the public would be in as much danger of being sold a conservation-management program or an income-management program on misleading grounds.

Most of you know of the efforts of the Food and Drug Administration to prevent the sale of fish and other foods under misleading names. Everyone agrees that in the long run this is to the best interest of the fishing industry. I think that this Commission, to the same extent, will find it advantageous to market its wares under an unambiguous label.

BIOLOGICAL AND ECONOMIC PROBLEMS OF FISHERY MANAGEMENT

By Robert A. Nesbit[1]/

The abundance of fishes and the productivity of the fisheries are affected by many natural influences over which we have no control. We cannot prevent or diminish natural mortality, nor can we influence migrations or rates of growth. But abundance and productivity are also profoundly affected by the fishery, and the fishery, unlike the natural influences, is susceptible of intelligent scientific control. It is, then, the primary business of this Commission to foster and develop a sound and permanent program of fishery management.

As we discuss and develop such a program, we must never forget that when we talk about managing a fishery, we are talking about managing fishermen. All of the schemes for managing fishermen ever proposed or adopted fall into one or the other of two classifications: (1) Those designed to control fishing intensity, i.e., to stabilize the percentage of the stock taken each year; and (2) those designed to promote selective fishing, i.e., to protect certain size or age groups in the stock. In the first group are such measures as closed seasons, prohibition of the use of efficient gear, limitation of the numbers of licenses, etc. The second group consists of minimum and maximum size limits together with measures to make them effective. Among the latter are closing of nursery areas to fishing, specification of minimum mesh sizes, etc.

THE BIOLOGICAL THEORY OF FISHERY MANAGEMENT

The Balance Between Natural Mortality and Growth

Let us see how these two kinds of management measures work out, singly and in combination. In order to do so it will be necessary to review briefly the theory of population growth and maintenance. First, let us see what happens in a fish population which is not being fished. Every new brood of fish starts with millions of newly hatched larvae. They are very small, so small that many millions weigh only a few pounds. They grow very rapidly, doubling their weight every few days at first--later they grow more slowly. In the meantime many are dying, but the total, i.e., the aggregate, weight of the survivors continues to increase. It will continue to increase as long as the rate of growth is greater than the natural mortality rate. Eventually, however, mortality losses exceed the gains from growth, i.e., the weight of the fish which die is greater than the weight gained by the survivors. Consequently, the aggregate weight of the brood declines and since, to paraphrase Swinburne, no fish lives forever, finally becomes zero.

1/ See p.69 for biographical data.

We can readily see how this works out by noting the changes in the aggregate weight of three species of fish with different rates of growth. As examples I have chosen the Pacific halibut, the whitefish of Lake Champlain, and the striped bass, because there are good accounts of the growth rates of all three species in the literature.2/

Suppose that we start with 1,000 five-year-old halibut. According to Thompson and Bell (1934) the average weight of fish of this age is 5.1 pounds, so that the aggregate weight would be 5,100 pounds. Now if the natural mortality rate is 10 percent per annum, 900 fish would live to become six-year-old fish. But each would weigh 6.2 pounds so that the aggregate weight of the 900 VI-group fish would be 5,580 pounds. If the natural mortality rate were 15 percent only 850 fish weighing 5,270 pounds would survive and if it were 20 percent only 800 fish weighing 4,960 pounds would survive. (See tables and figures following p. 42.)

Methods of Approaching the Optimum Yield

From the point of view of fishery management, this phenomenon is of great importance. We want to get the maximum yield out of each brood of fish. Assuming a 15 percent natural mortality rate, if we were to catch every halibut as soon as it became 5 years old the total catch would be only 5,100 pounds. But if we waited until all of the fish were 10 years old the total catch would be 6,083 pounds. If we waited until all of the fish were 25 years old the catch would fall to 4,446 pounds. So we can see that the best yields could be secured by waiting until the full benefits of growth have been realized and then catching the fish before natural mortality has begun to reduce the total weight of the brood. (Table I and figure I illustrate how the aggregate weight of 1,000 fish of the 3 species would change at different natural mortality rates.)

In practice we cannot wait until each brood is just the right age and then catch all of the fish in the brood. We must be content with an approximation. No method of fishing is so selective as to sort out particular age groups for capture. But if we can establish a minimum size limit and devise practical means for sorting out most of the younger fish it is obvious that substantial benefits will result. It follows then, that we should always

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2/ For accounts of these species see the following:

Thompson, William F., and F. Heward Bell. Biological statistics of the Pacific Halibut Fishery, Report of the International Fisheries Commission, No. 8, 1934.

Van Oosten, John, and Hilary J. Deason. The age, growth, and feeding habits of the whitefish, Coregonus clupeaformis (Mitchill), of Lake Champlain. Transactions of the American Fisheries Society, 1938.

Scofield, Eugene C. The striped bass of California (Roccus lineatus). California Division Fish and Game, Fish Bulletin No. 29, 1931.

(The data for whitefish and striped bass were smoothed and the growth curves of all three species were extrapolated to provide estimates of the weight of very old fish, such as would be present in the population at low mortality rates.)

seek to establish a minimum size limit whenever it is practicable to do so. In actual practice however, the costs of selective fishing are often so great as to nullify much of the benefit. For example, it is necessary for practical reasons to use a rather small mesh in pound nets, small enough to retain practically all individuals of all species. Sometimes it is possible to sort out small fish of certain species by "sifters," but when the catch includes many species, as it usually does, hand sorting is the only means available. This is not only costly, but delicate species, such as butterfish and weakfish, do not survive the handling. In such instances little or nothing would be gained from the trouble and expense of sorting.

Fortunately, however, as Thompson and Bell have demonstrated, the essential benefits of minimum size limits can often be realized simply by reducing the rate of fishing and without fishing selectively at all. A simplified example will illustrate the principle which can then be developed in greater detail. Suppose that we have a very intensive fishery, one that removes 80 percent of each brood in a year. Disregarding natural mortality, out of 1,000 fish just entering the fishery 80 percent of the youngest age group would be caught, leaving only 200 fish for the next year. If the fishing rate were lowered to 20 percent 600 fish of this youngest group would be protected just as surely as if they had been caught by a highly intensive fishery and then thrown back into the water. Most of them would be caught eventually, but only after they had benefited by the same chance to grow that a size limit would have given them. Note that simply fishing at a lower rate is nearly as effective in protecting the youngest age group as is a perfectly efficient sorting method.

The effects of both conservation methods are similar in another respect—they increase the average size and age of the fish caught. The large fish of most species are considered more desirable and are worth more per pound. And, of course, both methods maintain larger stocks of better quality fish in the water, a consideration of primary importance to the large and growing group of salt-water anglers.

Mathematical Methods for Estimating the Effects of Fishing

In the foregoing example natural mortality was disregarded in the interest of simplicity. Actually, changes in the fishing rate do not lead to exactly proportional changes in the numbers caught and the numbers surviving. Before working out further examples in detail it is necessary to see how natural mortality rates and fishing rates are combined to give total mortality rates. We are indebted to Thompson and Bell for the methods used in this discussion.

The effect of the fishery is to increase the mortality rate, hence to hasten the day when a brood disappears from the ocean. The new mortality rate is not the simple sum of the natural mortality rate and the fishing rate but always something less. For example, suppose that a million shad run into a river in which there is no fishery and that the natural mortality rate is 20 percent per annum. A year later 800,000 survivors will return; two years later 640,000; three years later 512,000 and so on. Now let us suppose that a very intensive fishery is established, one which takes 80 percent of each year's run. The first year 800,000 fish will be caught and

200,000 will escape. Of these 20 percent will die so that 160,000 will return. Of these returning fish 80 percent, or 128,000 will be caught and 32,000 will escape. Twenty percent of these will die so that only 25,600 will return the next year. Note that 160,000 is 16 percent of 1,000,000 and that 25,600 is 16 percent of 160,000. This 16 percent is the survival rate, so that the total mortality rate is not 80 percent plus 20 percent, but is 100 percent minus 16 percent or 84 percent.

The shad is a special case of the general theory established by Thompson and Bell. It is special in that the fishery takes its toll in a very short time while natural mortality continues over the whole year. Most fisheries are conducted on a year-round basis so that both fishing mortality and natural mortality go on simultaneously. That means that some fish are caught which otherwise would die naturally before the end of the year and that some fish die naturally which would have been caught had the fishery been concentrated at the beginning of the year. Thompson and Bell show that the total mortality is the same as if the two rates were applied instantaneously and successively and that the distribution of the total mortality between fishing mortality and natural mortality is proportional to the two rates. Applying this to the examples just given, if shad fishing were spread out over a year, a combination of an 80 percent fishing rate and a 20 percent natural mortality rate would cause a total mortality of 84 percent just as in the examples given, but of the 840,000 fish removed from the stock, only 672,000 would be caught instead of 800,000 as in the examples given. That is, if the fishery takes its toll first, 80 percent of 1,000,000 fish would be caught, but if it is spread evenly over the year, only 80 percent of 840,000 fish would be caught.

This more general treatment has been applied to the growth data of the three species used as examples above. (We do not know the natural mortality rates for any of these species, so it is necessary to compare the effects of various fishing rates and size limits for each of several possible natural mortality rates.) The results are set forth in tables II, III, and IV, and are illustrated in figures II, III, IV. These tables and figures indicate what would happen to 1,000 fish of each species under various conditions of fishery management.

Illustrative Examples

Let us choose a few illustrative examples. Striped bass begin to appear in the nets when they are about one and one-half years old, i.e., in the autumn of their second year of life. They are designated in the table as age group I, and on the average they weigh about one-half pound. If the natural mortality rate is 20 percent and the fishing rate is 80 percent, 672 would be caught as in the example given above. These would weigh 672 x .5 pounds or 336 pounds; 168 would die and 160 would survive for the next year's fishery. The survivors would now weigh 1.2 pounds each. Of the 160 survivors, 108 would be caught and would weigh 108 x 1.2 or 130 pounds. The next year only 17 fish would be caught. These fish would weigh 17 x 2.4 pounds or 41 pounds. If this be continued until all of the fish have been caught or have died, the sum of the weights of all of the fish caught will give the total yield from each 1,000 fish of the brood. In this instance it is 521 pounds (Table IIc (1)). This is very little more than would

have been taken if the whole brood had been caught as soon as the fish were big enough to catch. A similar computation and summation shows that if the fishing intensity were reduced to 20 percent the yield would be 1,524 pounds--nearly three times as much.

These tables are intended to show what happens to each brood over a period of several years, but the totals are also indices of the average annual catch. If, instead of the 1,000 fish which we have used in the tables, exactly a million half-pound fish are provided by reproduction each year, the total catch each year would be 521,000 pounds at an 80 percent fishing rate and 1,524,000 pounds at a 20 percent fishing rate. But at the 80 percent rate the average level of abundance would be only 624,000 pounds and of these only 4,000 pounds would be large enough to spawn. At the 20 percent rate there would always be 5,919,000 pounds of fish in the water and of these 3,956,000 pounds would be big enough to spawn.

Now these computations have been based on the assumption that reproduction would take care of itself, that is, that even the 4,000 pounds of spawning fish which would be in the water at an 80 percent fishing rate would be enough to maintain an average annual increment of 1,000,000 half-pound fish. That may be true for striped bass, which is notoriously subject to great variation in success of reproduction and which sometimes produces very large broods when spawners are scarce. But for many species it is not safe to depend on very small reserves of spawners as our sad experience with shad and haddock proves. However, even if an 80 percent fishing rate has no adverse effect on reproduction, a lower rate will produce more pounds of fish from the same reproductive increment. Moreover, the cost of maintaining a lower rate of fishing is much less. It follows that the profits, the real income, the money which fishermen can spend, would be much greater. Three times as much fish, (table II-c (1)) produced at one fourth the expense for gear and operation, would increase the real income from the fishery twelvefold.

Let us now consider the effect of a minimum size limit which would protect two age groups so that the average weight of the fish entering the fishery is 2.4 pounds. The 1,000 fish with which we started would have been subject to two years of natural mortality at 20 percent per annum, so that 640 fish weighing 6,650 pounds would be available instead of 1,000 fish weighing 500 pounds. Applying the same computations as before we find (table II-c (3)) that an 80 percent fishing rate would yield 1,412,000 pounds on the average from a stock receiving annual increments of 1,000,000 half-pound fish. That is not quite as much as a 20 percent fishing rate would yield without any size limit. But if we maintain the size limit and reduce the fishing rate to 20 percent too, the average yield will increase to 2,030,000 pounds a year. So, if striped bass are subject to a 20 percent natural mortality rate, either an increase in the size limit or a reduction in the fishing rate will increase the yield about threefold and if both methods are used the yield will be increased fourfold and the real income from the fishery increased sixteenfold.

It was on the basis of such computations based on the data of Dr. Daniel Merriman, Dr. Vadim Vladykov, and Mr. Eugene Scofield, that the former Bureau of Fisheries recommended an increase in the minimum size limit for striped bass on the Atlantic Coast. At the time the recommendations were

made, there appeared to be no possibility of reducing the fishing rate.

Such computations are not entirely theoretical. They serve to explain actual biological observations. The following are examples of observed total mortality rates within the range included in the tables: Thursby-Pelham3/ observed that as soon as plaice in the North Sea got big enough to be taken by the fishery each brood is reduced in abundance at the rate of about 55 percent a year. Raitt3/ showed that the introduction of the efficient V. D. gear in the North Sea haddock fishery increased the total mortality rate from 50 percent to about 65 percent in a few years. He estimates that the fishing rate increased 50 percent. Such tables are useful even if we do not yet have precise information as to fishing rates and natural mortality rates. They indicate the range of possibilities and the limitations imposed by nature on the usefulness of the only two methods available for increasing the productivity of our fisheries.

For us biologists in particular, such tables are helpful in planning and organizing our research programs. One of the reasons that we know so little about fishing rates and mortality rates is that some of us, including myself, have not fully appreciated their importance, hence have not tried very hard to measure them. Given necessary facilities, including good catch records, we will be able eventually to make very close estimates of the constants used in the computations.

From these tables it is clear that if natural mortality rates are very high relative to growth rates, there is nothing we can do except to protect enough of the spawning reserve to insure regular future increments. That is the problem with the salmons of the Pacific, in an extreme form. Nature herself imposes a very effective minimum size limit. But after spawning the growth rate is zero and the natural mortality rate is 100 percent. Since all Pacific salmon die after spawning, it is necessary to maintain a high fishing rate in order to catch as many fish as can be spared from the spawning reserve. If the rate were set too low, excessive escapement would waste fish.

In some instances it might be possible to set a minimum size limit high enough to create an adequate spawning reserve among the protected age groups. For example, again assuming a 20 percent natural mortality rate, if the size limit on striped bass were established at a length that would protect four age groups, so that no fish should be caught until it had spawned once, the yield would be about the same at all fishing rates from 20 percent to 80 percent (table II-c (5)). Under such circumstances, a high fishing rate would not reduce future yields. It would, however, be less profitable than a lower rate because of higher costs for gear and operation. The extra gear used to maintain the high rates would be wasted and so would the work of the extra fishermen.

3/ Conseil Permanent International pour L'Exploration do la Mer: Rapports et Procès-Verbaux des Reunions. Vol. CX, Contributions to Special Scientific Meetings, 1939. Copenhagen.

As may be seen from table II-e, (5), for species subject to high mortality it would be possible to set the minimum size limit so high that only a high fishing intensity would produce maximum yields, but this would be undesirable again because of the high costs of high fishing rates and of the waste of manpower and equipment.

The Importance of the Fishing Rate

The foregoing indicates the great importance of the fishing rate in fishery management. In summary it may be said: (1) In the many instances in which minimum size limits are impracticable, control of fishing intensity is the only conservation method available. (2) Even when it is feasible to establish minimum size limits, it is still necessary to stabilize fishing rates at low or moderate levels, because reduced fishing rates not only increase the effectiveness of the size limits, but reduce the cost of fishing as well.

In view of these facts, it is obvious that the success or failure of this Commission depends on whether it is able to bring about control of fishing rates. For some species, such as striped bass, lobsters, and haddock, a partial job can be done through size limits alone, but the full usefulness of even these resources cannot be realized unless the fishing rates and fishing costs are also reduced to and held at the minimum necessary to produce full yields. I can think of no more important subject for the consideration of the Commission than ways and means for controlling fishing rates, or as I prefer to think of it, ways and means for enabling fishermen to control the rate of fishing. Let us then proceed to a study of how fishing rates can be controlled.

CONTROL OF FISHING RATES

Two Ways to Exercise Control

The magnitude of the fishing rate is a function of the number of operating units and of the efficiency with which they are operated. Each operating unit is capable of taking a definite percentage of the population when operated normally and on a full-time basis. If the rate be excessive, it can be reduced only by eliminating some of the units or by requiring each unit to operate at less than capacity, i.e., to operate inefficiently.4/

4/ The term "operating unit" is used here instead of "unit of gear" in order to avoid confusion with the technical use of the latter term in connection with such indices of abundance as the catch per unit of gear. These indices also measure one aspect of efficiency. For example, abundance of scup or weakfish might be expressed in terms of the catch per pound net per season, and fishing would be a more efficient operation at the higher levels of abundance. But pound nets are not operated singly. Each operator sets from 2 to 5 nets which are serviced by a single pound boat and crew, and this group of nets and its accessory equipment constitutes an operating unit in the economic sense. In this economic sense, efficiency is an attribute of the whole operating unit and not of its parts. If an attempt

The biological effects of both methods for reducing the fishing rate are the same. But the social and economic consequences are vastly different. It is desirable to indicate the principles in a diagrammatic manner, using a simple hypothetical case. Illustrations from actual experience can then be used to show how these principles work out in practice.

A Hypothetical Illustration

Let us assume that we are dealing with a lake in which 80 gill-net fishermen operate 12 months of the year. Each fisherman catches 20,000 pounds of fish a year, which he sells for 10 cents a pound, so that his gross income is $2,000. His expenses are as follows: Fixed annual expenses for depreciation and maintenance of boat and nets, $500; operating expenses such as gas and oil, which vary directly according to the number of days that he actually fishes, $500. His net income therefore is $1,000 per year. Each fisherman takes 1 percent of the fish in the lake so that the annual fishing rate is 80 percent and the total catch is 1,600,000 pounds a year.

Now let us assume that this rate is excessive and that a 20 percent fishing rate would yield three times as much. (cf table II-c, (1)). There are two ways, and only two, to reduce the fishing rate: (1) to reduce the number of fishermen and (2) to reduce the amount of fishing that each one does. If the second way were chosen it could be accomplished in several ways, for example by requiring each fisherman to use only one-fourth as much netting, or by permitting fishing for only 3 months in the year, or by permitting each fisherman to fish for only one week in each month or only one day in each four. For the first year the catch of each fisherman would be reduced to 5,000 pounds and his gross income would shrink to $500, just enough to pay his fixed expenses with nothing left to pay for gasoline, or for his living expenses. But let us suppose that the banks advanced credit to all of the fishermen until the benefits of reduced fishing intensity were realized. Abundance and yield would be greatly increased and each fisherman could catch more fish in three months than he could in a year before the closed season was imposed. Then each fisherman would have a gross income of $6,000 while his expenses would be reduced to $625 (fixed expense of $500 plus $125 for variable expenses). His net income would be $5,385 and he would be a gentleman of leisure as well. Each fisherman would receive more than five times as much money for one-fourth as much work.

That would be a rather attractive prospectus to present to such a group of fishermen when seeking their support for legislation imposing the closed seasons. But there is a catch in it. At the start there were just 80 fishermen, not 60 and not 100. That was because the prospect of $1,000 a year would attract and hold just 80 fishermen. But if the income is

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be made to reduce the amount of gear by requiring that each operator use less than the normal or customary number of nets, the proposal falls in the second class above, i.e., it is not a proposal to reduce the number of operating units but a proposal to diminish the efficiency of each unit.

increased to more than $5,000 a year and the hours of labor are reduced new fishermen will rush in until competition reduces the average annual income to $1,000 again. Depending on the kind of regulations adopted, there are two ways in which the decrease in annual income might be brought about. Under the regulations each fisherman would contribute one-fourth of 1 percent to the total fishing rate of 20 percent. Each new fisherman would add another one-fourth of 1 percent so that the fishing rate would increase again. That would again reduce the yield and with it, the gross income of each fisherman.

Suppose, for example, that 80 more fishermen took out licenses, increasing the fishing rate to 40 percent. The yield would fall to 3,200,000 pounds and the gross income of each fisherman would fall to $2,000. After deducting expenses the net income would fall to $1,385. That would still attract a few more fishermen and in the end the fishery would become stable again with a yield of about 3,000,000 pounds a year and with about 175 fishermen, each employed on a demoralizing part-time basis, with an income of $1,000. The decrease in income might be brought about in another way. The closed season might be changed from year to year in accordance with the numbers of fishermen licensed. Then the fishery would come to stability with 100 fishermen fishing one day a week and earning a gross income of $1,600 and a net income of about $1,030.

Now let us see how it would work out if the fishing rate were reduced by eliminating fishermen. Twenty fishermen would be able to do the job 5/ working full time. This yield would increase from 1,600,000 pounds a year to 4,800,000 pounds and remain there without further changes in law or regulation. (Unless, of course, some one were to invent a better gill net). The total value of the catch would be $480,000 and the gross income of each fisherman would be $12,000. After deducting $1,000 expenses he would have $11,000 a year net income. Each fisherman could then well afford to pay a very substantial license or franchise fee, sufficient at the very least to defray administrative and research costs.

Illustrations from Experience

As far as I know, no actual fishery has ever run through the whole series of changes outlined in this hypothetical example, but there are a number of examples from actual experience of the workings of the economic and biological laws involved. The Commissioners from New York and New Jersey will recall that the license rolls more than trebled as soon as word got around that the shad were back in the Hudson. A similar "gold rush" occurred in Maryland when the 1934 brood of striped bass appeared in the fishery in 1936. As one fisherman put it, (I quote from memory) "When rock were scarce, we regular fishermen could run all day without seeing another boat and we didn't make any money. But when the rock came back, every storekeeper in town put out a line of credit to fellows who never had fished before. Old netting that hadn't been wet for 10 years came out

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5/ This is an over-simplification. Actually there is competition between gear, so that less than 20 fishermen would be needed. Thompson and Bell give a logarithmic formula for computing the amount of gear to be added or dropped in order to increase or decrease the fishing rate.

of attics and barn lofts and it got so that a regular fisherman had to run for two hours to find a place to set his net. There were so many fishermen that nobody made any money."

The biological and economic history of the Pacific halibut fishery is the most nearly complete and the best documented illustration of the effects of reducing the fishing rate by imposing inefficiency on the fishermen. The following is intended as a critical account of the results of a particular policy, and is definitely not intended as a criticism of the International Halibut Commission, or of its technical staff. On the contrary, I have chosen the halibut program as an example because the Commission and the technical staff have carried out their responsibilities so well. By the terms of the treaty creating the Commission it has no option as to the methods employed to reduce the fishing rate. The Commission has exercised its discretionary powers with conspicuously good judgment, and the scientific work which preceded and accompanied the program is one of the classic achievements of modern fishery biology. I am, however, frankly critical of the policy, which, as I shall endeavor to show, greatly limits the usefulness of a brilliantly executed program.

Since 1932 the fishery has been subject to regulation by the Commission. Four areas were established and for the two main areas the Commission established annual limits for the total catch. When the limit from each area is reached, the area is closed to fishing for the year. Since for any level of abundance the amount caught is a definite percentage of the stock, the effect of the regulations is to close the season as soon as the desired fishing rate has been attained. The initial quotas were set low enough to correspond to a reduction in the fishing rate, so that abundance increased. As it increased the fixed quotas became smaller and smaller percentages of the stock, so that in effect the Commission has gradually reduced the fishing rates. From time to time increases in the quotas have been authorized. It may be noted that the fixed-quotas device automatically compensates for increases in the numbers of fishermen. When additional vessels are attracted by increased abundance the season is automatically shortened and the low fishing rate is automatically maintained. And, just as in the hypothetical example, the gross income of each fisherman is automatically reduced, because each must share the total income with more fishermen than before.

In an article in the 1942 Year Book Number of the PACIFIC FISHERMAN, H. A. Dunlop and F. Heward Bell summarize the accomplishments of the Commission as follows:

> "Results of Limitation. The object of the Commission has been to stop the decline of the fishery in both areas and to build up and maintain the stocks of fish at a high level of productiveness. The first object has been achieved and much has been done toward the attainment of the second.
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> "Under regulation, the condition of the stock in Area 3 has shown a marked improvement. The catch per skate has risen from 64 pounds in 1930 to 122 pounds in 1941, an increase of 91 percent. The average size of the fish is larger, indicating the presence of a greater supply of fish of spawning size. The stock is in good condition, though the rate of improvement, at first rapid, has slackened during the last few years.

"The condition of the Area 2 stock is also greatly improved. The catch per skate has risen from 35 pounds in 1930 to 62 pounds in 1941, a 77 percent increase.

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"Many other changes which cannot be dealt with here have occurred in the fishery. Noteworthy among them are a shortening of the fishing season, the addition of many new vessels, particularly in the spring and early summer, and changes in the distribution of the catch among the different classes of boats. These developments have had an economic basis, in part, though the improved condition of the stocks themselves has also been responsible.

"Control Improves Pacific Halibut Fishery - The Pacific halibut fishery is both biologically and economically far improved over what it was prior to regulation and over what it would now have been had it been allowed to run its uncontrolled course. Without control the amount of fishing would have been determined solely by the balance existing between the cost of fishing and the price paid for the product. It is conservatively estimated that under such conditions the catch would not now exceed 40,000,000 pounds annually. In contrast, under rational control the catch in 1941 was 53,000,000 pounds, 10,000,000 over what it was in 1931 immediately prior to regulation or 13,000,000 greater than it might have been today without control. At present prices this gain in catch is worth more than $1,000,000 annually to the fishermen.

"Due to the increased size of the stocks of halibut, far less fishing effort is now required to secure greater catches than formerly. Thus in 1941, 23 percent more fish was taken with 22 percent less fishing effort than in 1931.

"The increased catch of halibut and the saving in man and fishing power required to secure it, which have resulted from the Commissions regulation of the fishery, should be of significant value to the people of the United States and Canada in the present emergency."

To this may be added the following quotation from an anonymous article in the same journal:

"Seattle Halibut Fleet Adds New Boats

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"At the very start of the season it was apparent that the size of the active halibut fleet had increased. There were a number of new vessels, new construction having increased the Seattle fleet by eight, which was only typical of the other ports. Furthermore, the prospect of good prices, amply borne out by the early auctions, served to attract to the fishery substantial numbers of boats from other branches of the business."

The following editorial from the COMMERCIAL FISHERMAN'S WEEKLY (No. 33, March 15, 1940, p. 7) also is pertinent:

"A Just Price for Halibut

"With the opening of the halibut season but fourteen days off--that is if the International Commission announces April 1 as the opening date which nobody seems quite certain it will--there is some speculation as to what prices will be paid this year.

"Of course, halibut are sold on the open market to the highest bidder and it is assumed that prices will be regulated by the market demand.

"But conditions are abnormal this year and though prospects are favorable--Canada has 700,000 pounds of halibut and the United States 2,000,000 pounds less in cold storage than a year ago; Britain is said to be hungry for halibut; Americans can buy our halibut at 11 percent discount--it is doubted whether the price paid the fisherman-producer will cover the substantial increase in his operating expenses.

"The halibut fishery is no longer considered to be particularly profitable. The large influx of boats, the government-controlled production limit, and the strict regulations imposed by the fishing fleet itself have brought the individual's earnings close to a minimum. This year, it costs more to live; prices have risen for equipment, for hooks and lines, twine and paint. A fair estimate puts the increased operating expenses this year at 20 percent.

"The question is whether this increase will be covered by the price paid the fisherman. A Fisheries Advisory Board was set up some time ago to advise the minister of fisheries as to the "orderly supplying" of fresh and frozen fish to British markets. It would have been a desirable thing to have fishermen represented on this Board because orderly supplying begins with the producer and no one could as him advance the initial problems (sic), including the matter of a suitable recompense for his labor and expenses."

So we see that the halibut program is working out very much in the manner outlined in our hypothetical example. Abundance, yield and gross income have increased but so have the numbers of fishermen, so that the individual can make no more in a year than formerly.

An interesting side light is provided by the unofficial regulations adopted and enforced by the fisherman's union. Naturally, as abundance increased, fish were easier to catch and each vessel could catch more fish per month. There were more vessels too. The open season became shorter and shorter, so that the halibut were being dumped in the market faster than they could be sold without price declines. The fishermen adopted rules to spread the fishing over a longer period. The following are excerpts from the 1941 regulations:

Trip Limits

4. The following limits on trips shall be observed:

Area 3 - 3,500 lbs. per man per trip by both American and Canadian vessels at all ports.

Area 2 - 2,700 lbs. per man when landed at Seattle.

2,800 lbs. per man when landed in British Columbia or Alaska by both American and Canadian vessels.

In addition to these limits, all vessels will be permitted to weigh out and retain without penalty a leeway of 100 lbs. per man per trip.

5. No vessel shall be permitted a limit for a greater number of men than vessels of the same class carried in 1936. No vessel shall be permitted a limit for more than 11 men regardless of size.

Layups

7. All vessels shall lay up 15 days at end of first and second trips and 10 days at end of third and all remaining trips except the last full halibut trip, for which no layup will be required. Vessels commencing halibut fishing late shall observe the same layups as those taken by vessels commencing on time.

11. No vessel shall fish sable or mixed cod during the regular layup following a halibut trip.

At first thought it might appear that the halibut program has not only increased production but that it has increased the efficiency of the fleet as well. The catch per unit of fishing effort has nearly doubled so that a vessel can now catch a good fare of fish in a much shorter time than formerly. But more careful consideration will show that the gain in efficiency from abundance has been exactly matched by a loss in efficiency from enforced idle time in port. Economically there is no difference between time wasted on the banks waiting for halibut to bite and time wasted in port in compliance with layup regulations. Economically the normal unit of fishing effort is the number of skates of gear which a vessel can set in a year. Biologically the catch per skate of gear is a useful index of abundance but economically the index of efficiency is the catch per vessel per year. The only valid criterion of efficiency is the ratio of what a vessel actually catches to what it is capable of catching in a year under optimum conditions of abundance maintained by scientific management. Proof that the halibut fishery has not gained in efficiency is to be found in the fact that the increases in abundance and yield have not been followed by increased profits per vessel. Originally profits were limited by inefficiency caused by depletion. Now they are limited by legally imposed inefficiency.

It is difficult to escape the conclusion that perhaps half of the vessels and half of the men in the halibut fleet perform no useful service for society and through no fault of their own are prevented from receiving the income and enjoying the standard of living which full application of

their ability would make possible.

A General Principle and Its Implications

Now this is an illustration of a perfectly general principle: whenever and wherever we seek to eliminate inefficiency caused by scarcity by imposing an artificial inefficiency, the two inefficiencies will automatically balance, and the average income of individual fishermen will remain the same. The total yield will increase and so will the aggregate profit but individual profit will not change. Unless the numbers of fishermen are stabilized, no improvement in abundance will benefit any individual fisherman.

This Commission cannot honestly tell a lobsterman that an increase in size limits will increase his income unless the increase is associated with effective measures to prevent increases in the numbers of lobstermen. It cannot tell a shad fisherman that a weekly closed period will increase his income unless new fishermen are prevented from sharing the benefits. The Commission cannot fairly expect cooperation and support from the industry if it refuses to face the indisputable fact that any conservation measure which does not include stabilization or reduction of competition can do nothing more than increase total yield and spread the work on a low-efficiency and low-income basis. To be sure, from the point of view of the general public, even that is better than continued depletion, but we can scarcely expect fishermen to share our enthusiasm for the public interest unless we can promise them some improvement in their present unenviable position. In the past we conservationists have had a ready answer to the question: What will this proposal do for the fish? But we have never been able to give a satisfactory answer to the fisherman's natural question: What will it do for me?

Review of Control Methods

The foregoing will serve to indicate the main features of a rather complex set of dynamic interrelations, some of them biological and some economic. These can be restated briefly as follows: Every fishery is capable of producing an optimum sustained yield. This yield can be realized only by maintaining a constant relationship between abundance, the spawning reserve, the best practicable minimum size limit, and the fishing rate. If either of the latter two be altered the whole structure becomes functionally unbalanced and the annual yield falls. In the great majority of cases, the dynamic balance requires that a high level of abundance be maintained. This creates an economic incentive for a fishing rate inconsistent with maintenance of the optimum level of abundance. That is why management is necessary. Another way of stating this is to say that the fishing rate is extremely responsive to economic influences. In order to hold it constantly near the optimum, it is necessary either to fix it arbitrarily by limiting the numbers of units engaged in the fishery, or to eliminate the economic incentive to increase the fishing rate. No one has yet found any way to eliminate this economic incentive except to impose a compensating inefficiency. If we abandon all attempts to control the fishing rate it will increase until the inefficiency caused by scarcity eliminates the incentive for expansion.

NEW POLICIES CREATE NEW PROBLEMS

The Need for Decision

This Commission faces the necessity for a clear-cut decision as to policy. Even if we make the fullest possible use of minimum size limits the main problem will remain unsolved until effective control of fishing rates is established. The Commission must make a choice among three possible courses; 1. Doing nothing, i.e., condoning the present inefficiency caused by overfishing. 2. Fighting inefficiency with an exactly balanced inefficiency. 3. Eliminating inefficiency by adjusting the numbers of workmen to the job to be done. For each of these three possible policies, there are appropriate programs of action. If the Commission considers the problems to be insoluble or thinks that either solution is worse than the problems themselves, we may as well go home and forget the whole business. If the Commission determines that, everything considered, it is more important to spread employment than it is to secure the benefits of more efficient and profitable use of manpower and equipment, then the Commission should support such measures as closed seasons and restriction or prohibition of the use of the more efficient methods of fishing, such as otter trawls and pound nets. But if the Commission decides that the economic evils of over-competition outweigh its economic and ethical advantages, then the Commission should adopt a program of gradual elimination of operating units in excess of those necessary for orderly and efficient harvesting of maximum annual crops.

For the Middle Atlantic region, I earnestly recommend that the Commission adopt a policy and program which will protect the fishermen as well as the fish. In one important respect, such a program will be easier to develop than a conventional program based on a policy of imposed inefficiency. The Commission can count on the political support of fishermen. Experience in Maryland shows that fishermen will support--even demand--a program of license limitation and Commissioner Tucker has made it abundantly clear how fishermen whom he represents feel about over-competition.

Some New Problems

As old problems disappear new ones rise to take their places. I have no desire to minimize the practical and ethical difficulties which will beset the Commission in its efforts to develop such a program. Experience as an advisor to the group which developed the Maryland plan has made me acutely aware of such difficulties and I can foresee additional difficulties when the Commission seeks to develop a program for a whole region instead of for a single State.

Foremost among the new problems are those concerned with (1) methods of eliminating surplus fishermen and (2) the methods of determining which fishermen shall be eliminated and which shall remain. Our fisheries should be developed, not only by the right numbers of fishermen but by the most capable fishermen. Under present competitive conditions only the best can survive. We must find an effective and equitable substitute for this very useful function of free competition. In Maryland, retirement and death of operators is expected to bring about some reduction, but no very

great reduction can be expected from this method. For as soon as enough operators have retired or died to bring about an improvement in income, retirements will cease and licenses of dead operators will be transferred by the executors of their estates. Even if the law were amended to eliminate transferability of licenses, license holders would incorporate. Corporations do not die, so that reduction will be halted before the biological and economic objectives of the program can be fully attained.

Suggestions for Solution

We are indebted to Mr. Ned Schaefer, a member of the advisory committee to the New Jersey delegation, for a suggestion as to how these problems might be solved effectively and equitably. It is based on his experience with the New York Stock Exchange, a limited membership organization. With the bursting of the speculative bubble in 1929, the turnover in securities fell below the minimum necessary to support all of the members in the style to which they were accustomed, or indeed, to maintain the full membership on a solvent basis. The market price of exchange seats dropped sharply. Naturally the weaker members sold their seats, but since the total number of competing members remained constant, there was no relief from over-competition. It was proposed that each member be assessed to create a fund for purchase and retirement of seats offered for sale. Except in instances of death, it would be the least capable brokers who would offer their seats for sale, so that in the long run, the program would reduce excessive competition, leaving the best brokers to perform the necessary functions of the exchange.

A similar method might be applied to the fisheries by levying an assessment on each licensee. From time to time, as the fund accumulated, the commissioners of each State could invite tenders of licenses and purchase for retirement those licenses offered at the lowest prices. In the event that biological studies indicate the need for additional operating units, new licenses could be assigned by competitive bidding.

This method would not only solve the problem of bringing about the necessary reduction in operating units in an equitable manner, but it would also set up the machinery for solving another problem which will arise in the future. Undoubtedly some fisheries will become extremely profitable. The benefits of conservation will increase the gross income from the fisheries as a whole and the costs of operation will be reduced by eliminating unnecessary gear. The net profit from the fishery as a whole will be greatly increased and will be divided among a smaller number of operators. It will be necessary to recapture for the public the excess profit above normal returns on investment and normal wages of management. Some of this will be needed to pay the costs of research and administration, which at present are met by direct appropriation.

The revolving fund will serve to keep a brake on excessive profit during the transition period, when operators are being gradually eliminated. To put it another way, the costs of purchasing equities will be met out of the surplus profits resulting from better conservation, and not from the public treasury. As soon as the number of operators is adjusted to the capacity of the fisheries the annual assessments which are no longer needed

to purchase equities will serve as excess profit taxes.

Accounting experience gained in the course of developing the program of gradual reduction will be available to insure a sound basis for determining the amounts to be assessed on each operator. This point is important. I have emphasized the desirability of protecting the fishermen as well as the fish. But it is just as essential to protect the interests of the public. The fishermen must pay a price for protection of their efficiency and profit. That price is detailed accounting, not only with respect to catches and to fishing effort but in financial matters as well. As long as fishing is conducted as a private business, on a dog-eat-dog competitive basis, fishermen have the same rights as other business men to keep their private affairs private. But, if fishermen are protected against overcompetition then profits and losses are no longer private affairs, and they must be prepared to account to the public for tho special benefits conferred upon them.

This suggestion may be fairly criticized on the ground that the cash value of licenses or franchises will increase so that men who have acquired them at nominal costs will be able to sell them at a premium later. The increment is unearned but it would be very difficult to devise equitable means of recpaturing it for the public. This is, of course, exactly the same ethical problem which arises in connection with all property rights. No satisfactory solution has ever been found. (Disciples of Henry George would say that one has been proposed.) Most privately owned land which is now valuable was originally acquired at very low prices, indeed much of it was granted outright, without cost. If I am correctly informed the title to the oyster beds in Great South Bay goes back to pre-revoluntionary grants.

On the other hand, the great ethical advantage of Mr. Schaefer's suggestion lies in the fact that while reducing the numbers of opportunities to engage in fishing, it preserves equality of opportunity to do so. Any citizen of each State will have fully as much freedom to become a fisherman as to become a farmer. In either case he will have to meet two requirements: (1) raise enough capital to acquire tools of production, or (2) purchase or lease a property right or its functional equivalent, one of a limited number of licenses. In both instances the purchase should be in free competition with other aspirants. The farmer must have farm machinery and live stock; the fisherman must buy a boat and gear. The farmer must buy or lease an area of land; the fisherman must buy or lease a franchise, on a freely competitive basis.

For occupations directly concerned with natural resources this is all there is to freedom of choice of occupation, and to equality of opportunity. When we speak of these principles we do not mean that everybody can become a farmer, a lumberman, a mine operator or a fisherman. We merely mean that everybody is equally free to compete for the limited numbers of opportunities in each of these occupations, so that only those who have the most of what it takes--capital and ability--can get in.

The limitations on total opportunity are set by the magnitude of the resources themselves. Only so much useful work can be done. If more

be applied, excess is wasted at best, and in the instance of the fisheries it is worse than wasted, it is destructive. The critical social problems are those concerned with how the total opportunity shall be divided and allocated. For fixed natural resources such as agricultural land and mineral deposits, the problem was easy. Opportunity was originally acquired by pre-emption and defined by a surveyor. Currently it is transferred by competitive bidding and it is protected by property rights. We are so used to thinking of property rights as an institution and their protection as a principle that we seldom think of their important economic function in the management of natural resources. For example, property rights protect the farmer in his need and his desire to work effectively. If I take up farming I do not cause my neighbors' land to yield fewer bushels per acre. But if I take up fishing, I reduce the catches of my fellow fishermen. The farmer owns an exclusive right to exploitation of a definite part of the total agricultural resources of the country. We propose to make it possible for a fisherman to acquire a similar right to exploitation, not of a definite part but of a definite proportion, of a fishery resource. In most instances we cannot define his proportion with surveying instruments, but by setting limits to the numbers of licenses granted, we can protect his right to an undiminished opportunity to serve himself and serve society to the full extent of his abilities.

It would be possible, of course, to preserve equality of opportunity by granting licenses by competitive bidding on an annual or other fixed-term basis. But that suggestion fails to take into account that fishing is not merely a business--it is also a way of life. When a man becomes a fisherman he chooses a life work. Part of his life savings are tied up in equipment, so that if he is outbid at the end of one year or even a five- or ten-year period, loss of his license would destroy the usefulness to him of his accumulated capital. But quite aside from his money interest in his license, he has also a morally valid equity in his occupation. He has invested more than money, he has invested himself. He has a valid right to continue his life work as long as he desires and as long as he is able to do so. This equity, this right, transcends considerations of the diminished efficiency of aging men. We should by all means put the opportunity to engage in fishing on a competitive basis, but it is by no means necessary or desirable to require a man to compete all his life, failing in the struggle perhaps when he gets too old to make enough from a gill-net license to compete in the bidding with younger men. Nor is it necessary or desirable that fishermen be required to give up all of the increased profits from better conservation in the form of competitively determined license fees.

Elsewhere in this report I have put a great deal of stress on efficiency, so much indeed as to justify the suspicion that I make it a fetish. But I hasten to disavow any intention to set up efficiency as the sole criterion of the social value of any policy. Efficiency is desirable, not for its own sake, but because it is capable of promoting human welfare, and only to the extent that it actually does so. In a purely economic sense, efficiency can be measured as we measured it above in terms of what an operating unit produces in a year compared with its productive capacity. But back of the operating units there are fishermen, and the efficiency of men as producers and consumers must be measured in terms of how they serve

and are served by the economic order, in a lifetime.

There are a number of other problems. Some are apparent now and others will arise to vex us when legislative proposals are drafted. But once the major outlines of policy are determined, these problems can, I believe, be worked out by discussion and negotiation.

It is not my intention to offer model legislation, or to present detailed blueprints for development of a program of license-quota restriction. Whether the Commission adopts this policy or its alternative, it is the responsibility of the Commission to work out the program.

I have only one general suggestion to offer--whatever you do, work out your proposals with the fishermen before drafting legislation. In States where there are active organizations of fishermen, make use of them as advisors and political propagandists. Where no such organization exists, create them as was done in Maryland. If you fail to do so, if legislative proposals are drafted wholly by officialdom, they will be defective because officials do not have access to many of the pertinent economic facts known only to fishermen. Moreover, in most State legislatures a bill known to be a fisherman's bill has a better chance for enactment than an administration bill.

SUMMARY AND CONCLUSIONS

Several years ago, when this policy of conservation by license control was still in the rough idea stage, your Secretary, Mr. Wayne Heydecker, suggested three criteria by which its merits should be judged. These are: Is the proposal biologically sound? Is it economically sound? Is it administratively sound? This report may be summarized by noting how our proposals measure up to these standards.

It is not necessary to dwell on the first point. The biological effects of reduced fishing rates are the same regardless of the method chosen to reduce them.

We have shown in some detail how elimination of waste of manpower and equipment will confer economic benefits on the public and on the fishermen. The whole saving will be a net social gain, to be distributed under the administration of the Commission between the fishermen and their employees on the one hand and the public on the other. Fishermen will be more efficient producers and better customers for other productive units in the national economy. And at the very least, recovery of potential income now wasted by competitive multiplication of costs will relieve the public of its present burden of costs of administration and research. This is no small consideration. The Atlantic Coast States and the Federal Government are now spending from general taxation about $500,000 annually on fishery research and administration.

As Mr. Heydecker uses the expression, "administratively sound," it covers several considerations. It includes such questions as: Is it politically feasible? i.e., can legislative sanction be secured? Is it enforceable? Is it equitable, and is it in accordance with democratic principles?

With respect to political feasibility it is sufficient to point out that recent experience in Maryland proves that it is possible for a group of fishermen, legislators, conservation officials and biologists to work together with mutual confidence and respect for the formulation and adoption of a comprehensive state-wide conservation measure based on the new policy. Only experience can tell us whether measures based on this policy can be enforced. I have endeavored to show that this policy can and should be made consistent with one of the major principles of democracy, freedom of choice of occupation, subject only to competition with others with similar aspirations.

As for conclusions, the Commissioners must draw their own. The biologist and economist can only point out the probable consequences of contrasting policies. In this instance I have tried to show that an overmanned fishery and an efficient and profitable fishery are contradictions in terms. In drawing their conclusions, the Commissioners must face the fact that they cannot spread employment and preserve economy, efficiency, and high standards of living, too.

Figure I-a

Striped Bass

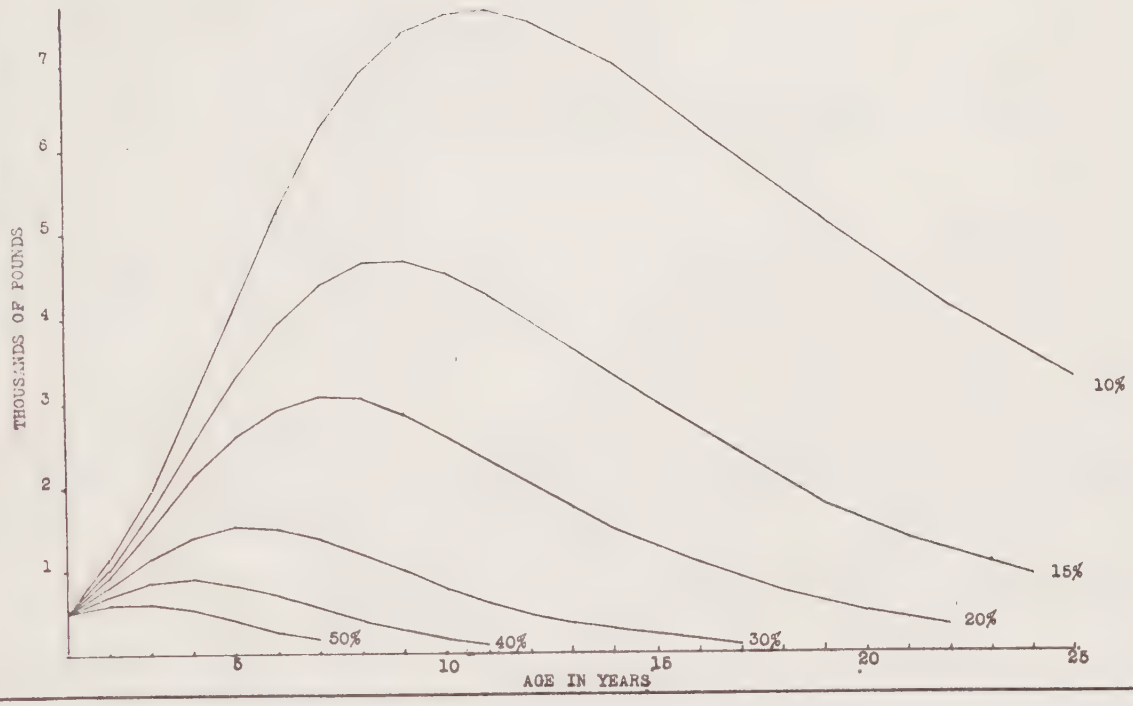


Figure I-b

Pacific Halibut

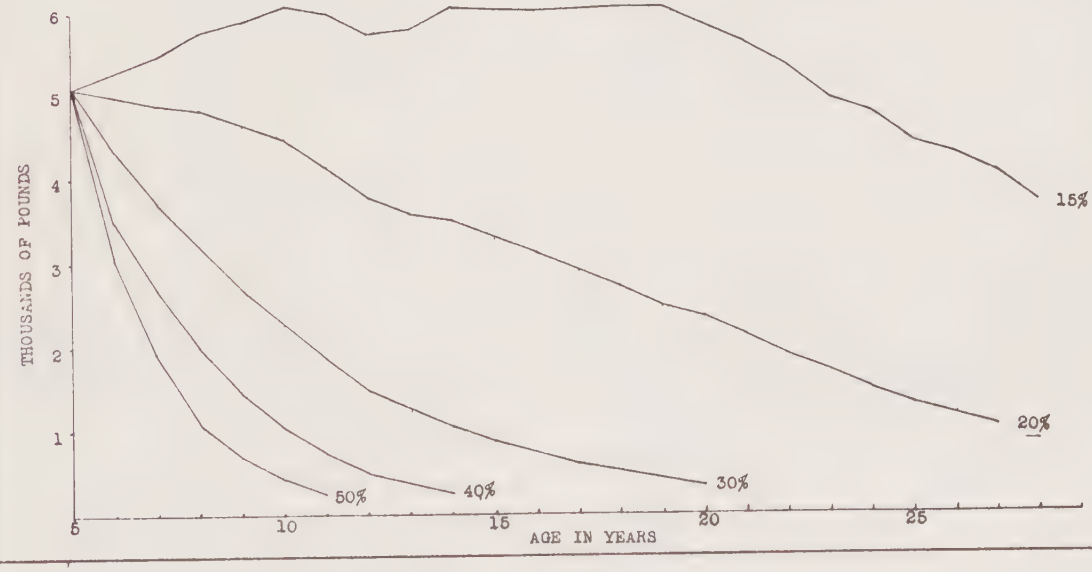
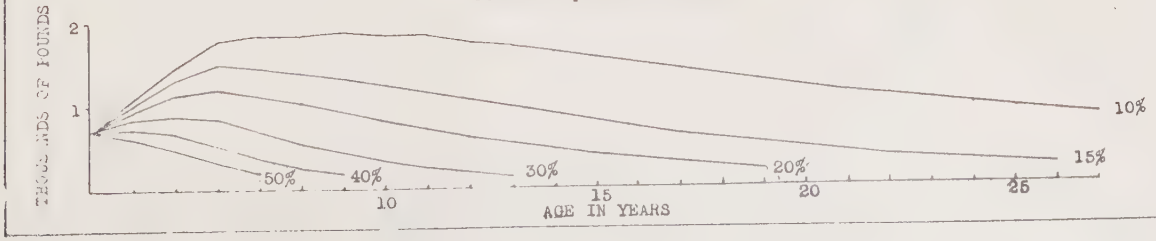


Figure I-c

Lake Champlain Whitefish



The Effect of Various Natural Mortality Rates on the Total Weight
of an Unfished Population Consisting Initially of 1000 Fish

Figure II-f (1)
50% Natural Mortality
No Size Limit

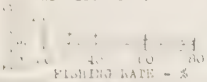


Figure II-f (2)
50% Natural Mortality
One Age Group Protected

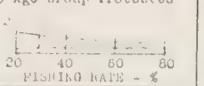


Figure II-f (3)
50% Natural Mortality
Two Age Groups Protected

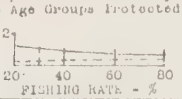


Figure II-f (4)
50% Natural Mortality
Three Age Groups Protected

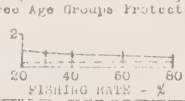


Figure II-f (5)
50% Natural Mortality
Four Age Groups Protected

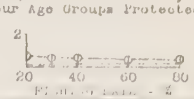
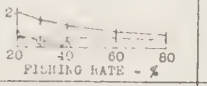


Figure II-e (1)
40% Natural Mortality
No Size Limit

Figure II-e (2)
40% Natural Mortality
One Age Group Protected



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40% Natural Mortality
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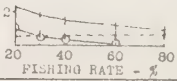


Figure II-e (4)
40% Natural Mortality
Three Age Groups Protected

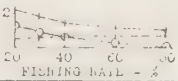
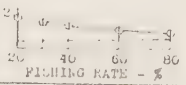


Figure II-e (5)
40% Natural Mortality
Four Age Groups Protected



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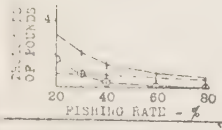
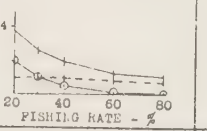


Figure II-d (2)
30% Natural Mortality
One Age Group Protected



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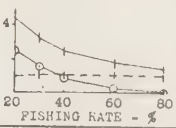
30% Natural Mortality
Two Age Groups Protected



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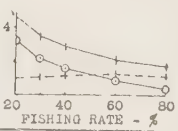
30% Natural Mortality
Three Age Groups Protected



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30% Natural Mortality
Four Age Groups Protected

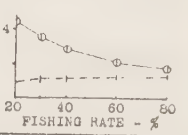

Figure II-c (1)
20% Natural Mortality
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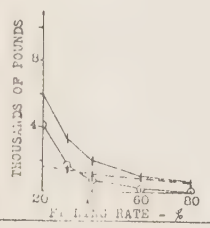

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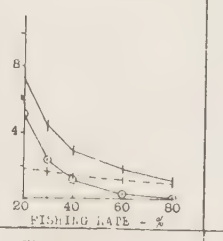
20% Natural Mortality
One Age Group Protected



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20% Natural Mortality
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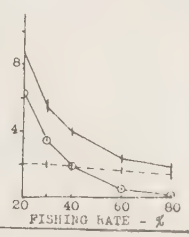
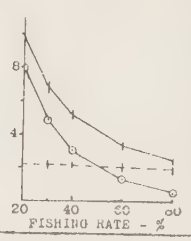


Figure II-c (4)
20% Natural Mortality
Three Age Groups Protected



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20% Natural Mortality
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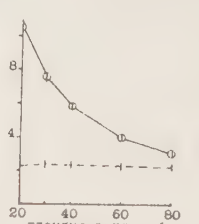

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15% Natural Mortality
No Size Limit

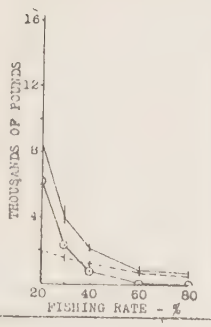


Figure II-b (2)
15% Natural Mortality
One Age Group Protected

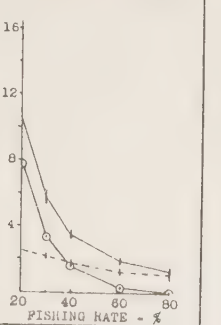


Figure II-b (3)
15% Natural Mortality
Two Age Groups Protected

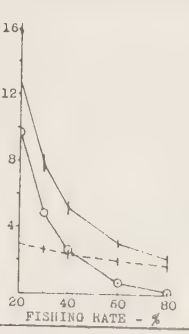


Figure II-b (4)
15% Natural Mortality
Three Age Groups Protected

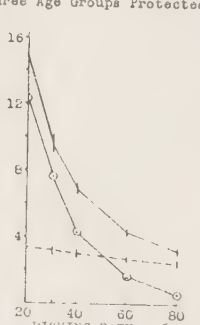


Figure II-b (5)
15% Natural Mortality
Four Age Groups Protected

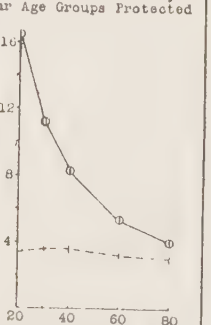


Figure II-a (1)
10% Natural Mortality
No Size Limit

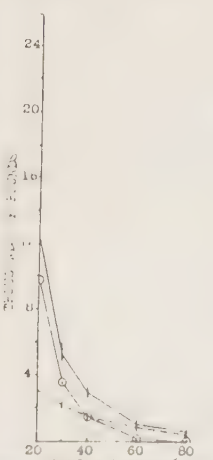


Figure II-a (2)
10% Natural Mortality
One Age Group Protected

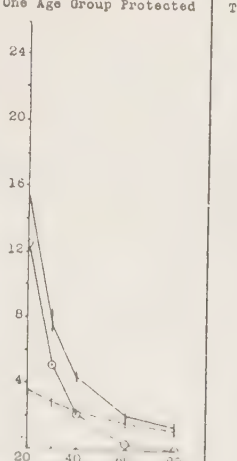


Figure II-a (3)
10% Natural Mortality
Two Age Groups Protected

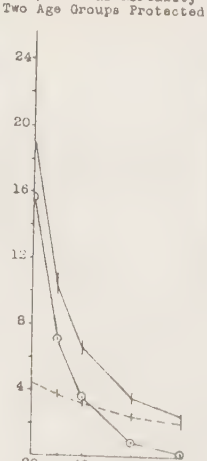


Figure II-a (4)
10% Natural Mortality
Three Age Groups Protected

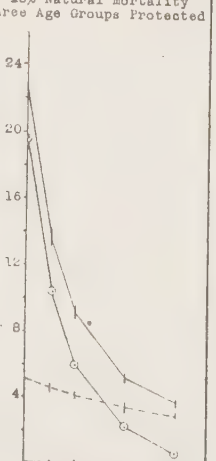
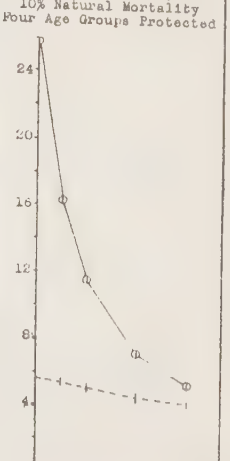
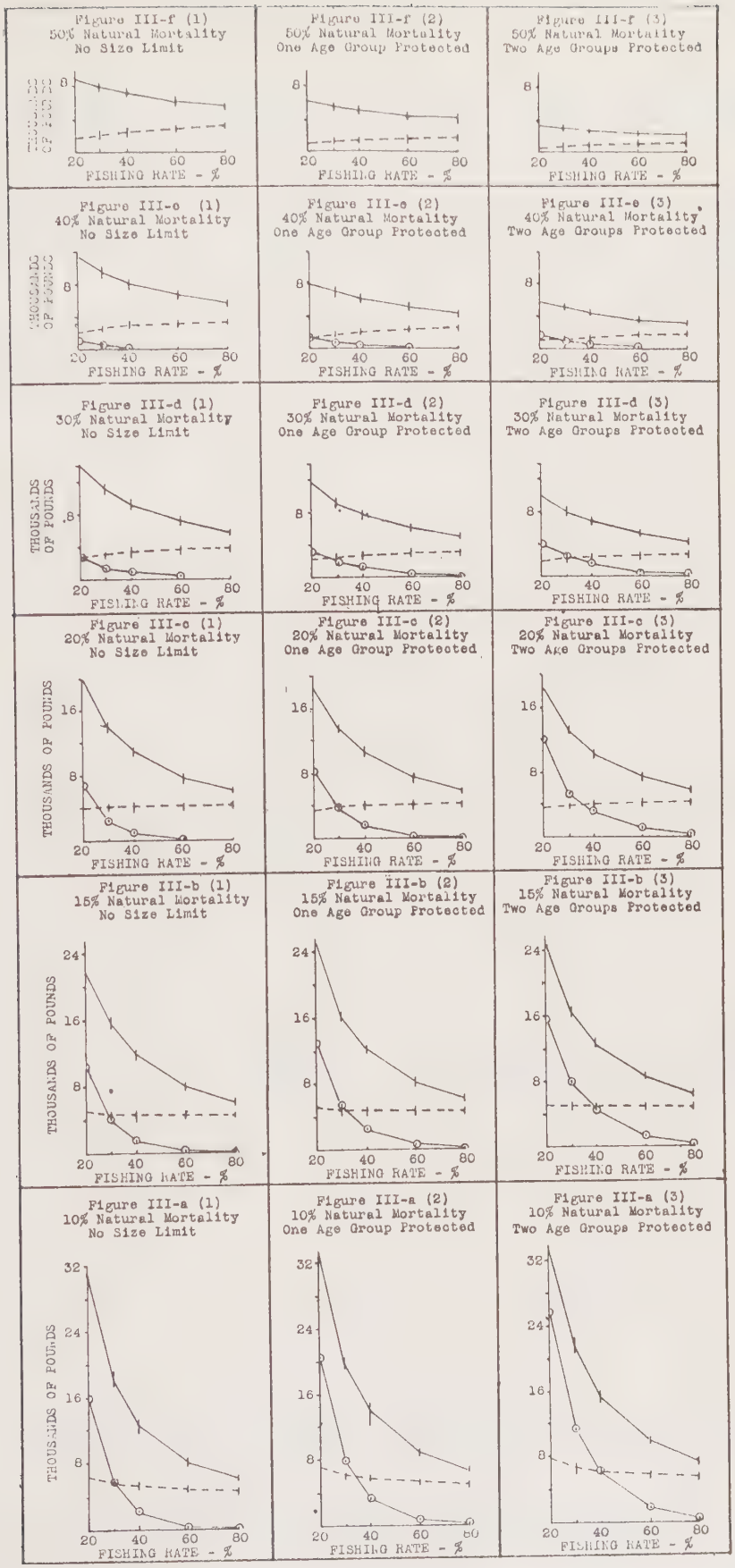


Figure II-a (5)
10% Natural Mortality
Four Age Groups Protected



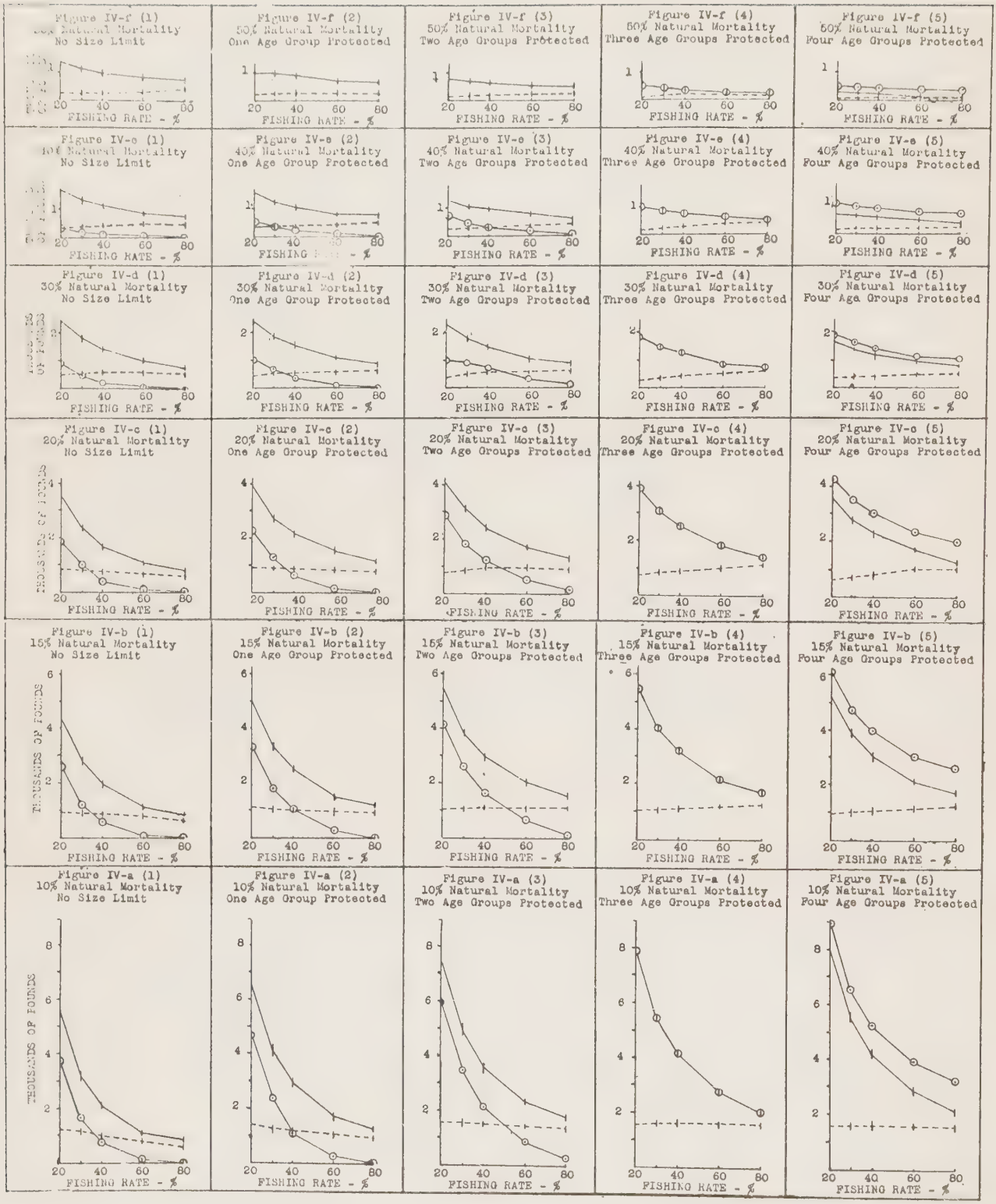
STRIPED BASS

Catch (⊢–⊢–+–+– ϕ), Abundance (⊢———+———⊣), and Spawning Reserve (⊢–o–o–o– ϕ), in Pounds per 1000 Fish at Various Rates of Natural Mortality and Under Various Conditions of Management.



PACIFIC HALIBUT

Catch (⊢ + ⊣ – –⊣), Abundance (⊢——+——⊣), and Spawning Reserve (⊃—o—o—⊂), in Pounds per 1000 Fish at Various Rates of Natural Mortality and Under Various Conditions of Management.



LAKE CHAMPLAIN WHITE FISH

Catch (⊢⊣–+–⊣), Abundance (⊢–+–+–⊣), and Spawning Reserve (⊢–o–o–o–⊣), in Pounds per 1000 Fish at Various Rates of Natural Mortality and Under Various Conditions of Management.

TABLE Ia.- Striped Bass

The Effect of Various Natural Mortality Rates on the Total Weight of an Unfished Population Consisting Initially of 1000 Fish of Age-group I

Item		Average weight per fish	Natural mortality rates (Percent)					
			10	15	20	30	40	50
		Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
Age-group	1	.5	500	500	500	500	500	500
Do.	2	1.2	1080	1020	960	840	720	600
Do.	3	2.4	1944	1734	1536	1176	864	600
Do.	4	4.2	3062	2579	2150	1441	907	525
Do.	5	6.4	4198	3341	2624	1536	832	400
Do.	6	9.0	5310	3996	2952	1512	702	279
Do.	7	11.8	6266	4449	3092	1392	555	189
Do.	8	14.6	6979	4672	3066	1197	409	117
Do.	9	17.3	7439	4706	2906	1003	294	69
Do.	10	19.7	7624	4551	2640	788	197	39
Do.	11	22.0	7656	4312	2354	616	132	22
Do.	12	24.1	7543	4025	2073	482	72	
Do.	13	25.9	7304	3678	1761	363		
Do.	14	27.7	7036	3352	1496	277		
Do.	15	29.3	6680	3018	1289	205		
Do.	16	1/30.9	6335	2688	1082	155		
Do.	17	1/32.4	5994	2398	907	96		
Do.	18	1/33.9	5627	2136	746			
Do.	19	1/34.6	5190	1834	623			
Do.	20	1/36.0	4860	1620	504			
Do.	21	1/37.4	4544	1421	411			
Do.	22	1/38.7	4218	1277	348			
Do.	23	1/40.0	3920	1120	280			
Do.	24	1/41.0	3608	943				
Do.	25	1/42.0	3360					

1/ Extrapolated values

TABLE Ib.- Pacific Halibut

The Effect of Various Natural Mortality Rates on the Total Weight of an Unfished Population Consisting Initially of 1000 Fish of Age-group V

Item	Average weight per fish	Natural mortality rates (Percent)					
		10	15	20	30	40	50
	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
Age-group 5	5.1	5100	5100	5100	5100	5100	5100
Do. 6	6.2	5580	5270	4960	4340	3720	3100
Do. 7	7.6	6156	5491	4864	3724	2736	1900
Do. 8	9.4	6853	5772	4813	3224	2030	1175
Do. 9	11.3	7413	5899	4633	2712	1469	706
Do. 10	13.7	8083	6083	4494	2302	1069	425
Do. 11	15.9	8443	5994	4166	1876	747	254
Do. 12	17.9	8556	5728	3759	1468	501	143
Do. 13	21.4	9202	5821	3595	1241	364	86
Do. 14	26.2	10139	6052	3511	1048	262	52
Do. 15	30.7	10684	6017	3285	860	184	31
Do. 16	1/ 36.1	11299	6029	3105	722	108	
Do. 17	1/ 42.5	11985	6035	2890	595		
Do. 18	1/ 50.0	12700	6050	2700	500		
Do. 19	1/ 58.8	13407	6056	2455	412		
Do. 20	1/ 67.4	13817	5864	2359	337		
Do. 21	1/ 76.0	14060	5624	2128			
Do. 22	1/ 85.0	14195	5355	1870			
Do. 23	1/ 94.0	14100	4982	1692			
Do. 24	1/ 106.0	14310	4770	1484			
Do. 25	1/ 117.0	14216	4446	1287			
Do. 26	1/ 130.0	14170	4290	1170			
Do. 27	1/ 145.0	14210	4060	1015			
Do. 28	1/ 160.0	14080	3680				
Do. 29	1/ 178.0	14240					

1/ Extrapolated values

TABLE Ic.- Lake Champlain Whitefish

The Effect of Various Natural Mortality Rates on the Total Weight of an Unfished Population Consisting Initially of 1000 Fish of Age-group III

Item	Average weight per fish	Natural mortality rates (Percent)					
		10	15	20	30	40	50
	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
Age-group 3	.7	700	700	700	700	700	700
Do. 4	1.2	1080	1020	960	840	720	600
Do. 5	1.8	1458	1301	1152	882	648	450
Do. 6	2.4	1750	1474	1229	823	518	300
Do. 7	2.8	1837	1462	1148	672	364	175
Do. 8	3.1	1829	1376	1017	521	242	96
Do. 9	3.5	1859	1320	917	413	165	56
Do. 10	3.8	1816	1216	798	312	106	30
Do. 11	4.2	1806	1142	706	244	71	17
Do. 12	4.5	1742	1040	603	180	45	9
Do. 13	4.9	1705	975	524	137	29	5
Do. 14	5.2	1628	868	447	104	16	
Do. 15	5.5	1551	781	374	77		
Do. 16	5.8	1473	702	313	58		
Do. 17	6.1	1391	628	268	43		
Do. 18	1/ 6.4	1312	557	224	32		
Do. 19	1/ 6.8	1258	503	190			
Do. 20	1/ 7.1	1186	447	156			
Do. 21	1/ 7.5	1125	398	135			
Do. 22	1/ 7.9	1067	356	111			
Do. 23	1/ 8.3	1008	315	91			
Do. 24	1/ 8.8	959	290	79			
Do. 25	1/ 9.3	911	260	65			
Do. 26	1/ 9.8	862	225				
Do. 27	1/10.3	824					

1/ Extrapolated values

TABLE II.- Catch, Abundance [illegible] in Pounds per 1000 Fish Available to the Fishery

STRIPED [illegible]

(a)-Ten Percent Natural Mortality

Item	Fishing rate (Percent)				
	20	30	40	60	80
(1) No size limit					
Catch	3070	2178	1560	900	601
Abundance	12344	5446	2790	1090	648
Spawning reserve	9949	3561	1282	142	6
(2) One age group protected					
Catch	3722	2916	2301	1569	1189
Abundance	15435	7700	4456	2110	1374
Spawning reserve	12489	5097	2161	361	29
(3) Two age groups protected					
Catch	4413	3697	3174	2447	2023
Abundance	18967	10336	6601	3550	2444
Spawning reserve	15661	7133	3586	899	150
(4) Three age groups protected					
Catch	5069	4582	4114	3454	3043
Abundance	22614	13464	9098	5329	3813
Spawning reserve	19552	10402	6036	2267	751
(5) Four age groups protected					
Catch	5628	5334	4985	4440	4068
Abundance	25905	16308	11512	7112	5202
Spawning reserve	25905	16308	11512	7112	5202

(b)-Fifteen Percent Natural Mortality

(1) No size limit					
Catch	2128	1644	1269	794	559
Abundance	8412	4122	2316	1011	636
Spawning reserve	6250	2391	926	107	4
(2) One age group protected					
Catch	2548	2160	1819	1328	1051
Abundance	10495	5780	3624	1875	1276
Spawning reserve	7864	3427	1562	274	23
(3) Two age groups protected					
Catch	2954	2699	2425	1977	1694
Abundance	12721	7682	5205	3008	2147
Spawning reserve	9778	4936	2602	687	115
(4) Three age groups protected					
Catch	3299	3191	3011	2658	2412
Abundance	14851	9615	6892	4295	3170
Spawning reserve	12268	7032	4309	1712	587
(5) Four age groups protected					
Catch	3536	3567	3484	3243	3050
Abundance	16497	11208	8333	5435	4089
Spawning reserve	16497	11208	8333	5435	4089

TABLE II (Cont'd.).- Catch, Abundance and Spawning Reserve in Pounds per 1000 Fish Available to the Fishery

STRIPED BASS

(c)-Twenty Percent Natural Mortality

Item	Fishing rate (Percent)				
	20	30	40	60	80
(1) No size limit					
Catch	1524	1272	1032	702	521
Abundance	5919	3199	1929	940	624
Spawning reserve	3956	1619	643	79	4
(2) One age group protected					
Catch	1794	1633	1431	1124	927
Abundance	7337	4423	2941	1665	1181
Spawning reserve	4974	2320	1070	204	18
(3) Two age groups protected					
Catch	2030	1973	1845	1593	1412
Abundance	8753	5720	4080	2536	1872
Spawning reserve	6207	3305	1806	510	91
(4) Three age groups protected					
Catch	2193	2245	2192	2032	1897
Abundance	9946	6911	5184	3425	2602
Spawning reserve	7796	4761	3034	1275	452
(5) Four age groups protected					
Catch	2258	2398	2415	2346	2262
Abundance	10653	7710	5967	4096	3163
Spawning reserve	10653	7710	5967	4096	3163

(d)-Thirty Percent Natural Mortality

(1) No size limit					
Catch	848	805	717	564	456
Abundance	3199	2047	1408	829	602
Spawning reserve	1619	727	309	43	2
(2) One age group protected					
Catch	952	970	925	814	718
Abundance	3871	2704	2012	1315	1001
Spawning reserve	2031	1044	527	109	10
(3) Two age groups protected					
Catch	1007	1082	1083	1030	963
Abundance	4380	3256	2548	1777	1392
Spawning reserve	2531	1498	878	270	52
(4) Three age groups protected					
Catch	1003	1119	1159	1166	1139
Abundance	4631	3591	2910	2121	1696
Spawning reserve	3190	2150	1469	680	255
(5) Four age groups protected					
Catch	937	1075	1139	1188	1192
Abundance	4518	3601	2980	2229	1803
Spawning reserve	4518	3601	2980	2229	1803

TABLE II (Cont'd.).- Catch, Abundance and Spawning Reserve in Pounds per 1000 Fish Available to the Fishery

STRIPED BASS

(e)-Forty Percent Natural Mortality

Item	Fishing rate (Percent)				
	20	30	40	50	60
(1) No size limit					
Catch	516	537	525	462	402
Abundance	1929	1408	1090	743	582
Spawning reserve	643	309	142	22	1
(2) One age group protected					
Catch	539	594	610	588	548
Abundance	2212	1724	1406	1029	832
Spawning reserve	806	452	240	53	4
(3) Two age groups protected					
Catch	519	597	634	649	636
Abundance	2301	1872	1578	1206	994
Spawning reserve	1020	645	400	133	26
(4) Three age groups protected					
Catch	462	547	597	639	648
Abundance	2187	1832	1579	1243	1040
Spawning reserve	1280	925	672	336	133
(5) Four age groups protected					
Catch	382	461	512	563	583
Abundance	1890	1611	1408	1128	951
Spawning reserve	1890	1611	1408	1128	951

(f)- Fifty Percent Natural Mortality

(1) No size limit					
Catch	338	382	395	384	359
Abundance	1200	1048	881	676	565
Spawning reserve	244	121	57	9	.65
(2) One age group protected					
Catch	317	373	402	417	412
Abundance	1339	1135	987	791	674
Spawning reserve	310	177	101	23	2
(3) Two age groups protected					
Catch	268	325	359	391	401
Abundance	1225	1067	947	779	672
Spawning reserve	387	257	167	59	12
(4) Three age groups protected					
Catch	207	256	289	325	342
Abundance	1007	893	803	774	587
Spawning reserve	432	368	278	149	62
(5) Four age groups protected					
Catch	146	183	209	240	257
Abundance	743	666	605	513	449
Spawning reserve	743	666	605	513	449

TABLE III.- Catch, Abundance and Spawning Reserve in Pounds per 1000 Fish Available to the Fishery

PACIFIC HALIBUT

(a)- Ten Percent Natural Mortality

Item	Fishing rate (Percent)				
	20	30	40	60	80
(1) No size limit					
Catch	6701	5879	5428	4982	4757
Abundance	30946	18447	13065	8370	6275
Spawning reserve	16025	5606	2230	262	12
(2) One age group protected					
Catch	7206	6389	5930	5465	5216
Abundance	33375	20084	14281	9167	6868
Spawning reserve	20290	8267	3654	789	64
(3) Two age groups protected					
Catch	7727	6927	6473	6015	5757
Abundance	33960	21881	15655	10104	7578
Spawning reserve	25333	11794	6174	1737	327

(b)- Fifteen Percent Natural Mortality

(1) No size limit					
Catch	5050	4893	4778	4597	4494
Abundance	23881	15884	11939	8060	6193
Spawning reserve	10142	3990	1641	207	10
(2) One age group protected					
Catch	5159	5036	4937	4757	4654
Abundance	25154	16368	12335	8333	6202
Spawning reserve	13123	5660	2685	521	50
(3) Two age groups protected					
Catch	5256	5172	5098	4953	4852
Abundance	25041	16893	12791	8684	6675
Spawning reserve	15832	8093	4524	1307	248

(c)- Twenty Percent Natural Mortality

(1) No size limit					
Catch	4005	4179	4237	4256	4258
Abundance	19340	13965	10967	7770	6114
Spawning reserve	6408	2748	1173	160	7
(2) One age group protected					
Catch	3865	4057	4124	4152	4148
Abundance	18703	13566	10670	7565	5949
Spawning reserve	8108	3873	1884	391	39
(3) Two age groups protected					
Catch	3721	3932	4016	4066	4070
Abundance	18094	13204	10424	7415	5833
Spawning reserve	10034	5588	3225	995	194

nt'd.)- Catch, Abundance and Spawning Reserve in Pounds per 1000 Fish Available to the Fishery:

PACIFIC HALIBUT

(d)- Thirty Percent Natural Mortality

Item	Fishing rate (Percent)				
	20	30	40	60	80
(1) No size limit					
Catch	2786	3212	3449	3713	3845
Abundance	13965	11272	9471	7266	5961
Spawning reserve	2748	1296	568	87	4
(2) One age group protected					
Catch	2367	2734	2941	3168	3278
Abundance	11870	9594	8068	6188	5074
Spawning reserve	3389	1839	969	222	21
(3) Two age groups protected					
Catch	2007	2328	2513	2717	2814
Abundance	10109	8198	6909	5309	4354
Spawning reserve	4278	2640	1624	539	107

(e)- Forty Percent Natural Mortality

(1) No size limit					
Catch	2118	2587	2906	3287	3500
Abundance	10967	9471	8370	6830	5816
Spawning reserve	1173	568	262	35	2
(2) One age group protected					
Catch	1546	1889	2125	2404	2557
Abundance	8002	6915	6111	4985	4243
Spawning reserve	1413	831	526	114	11
(3) Two age Groups protected					
Catch	1129	1385	1560	1768	1892
Abundance	5864	5076	4491	3666	3121
Spawning reserve	1814	1193	772	270	58

(f)- Fifty Percent Natural Mortality

(1) No size limit					
Catch	1703	2165	2499	2940	3215
Abundance	9064	8209	7510	6447	5680
Spawning reserve	437	239	121	19	1
(2) One age group protected					
Catch	1038	1320	1523	1791	1957
Abundance	6221	5695	5269	4621	4153
Spawning reserve	581	341	191	49	5
(3) Two age groups protected					
Catch	634	807	933	1098	1200
Abundance	3378	3059	2799	2403	2117
Spawning reserve	724	498	333	126	26

TABLE IV.- Catch, Abundance and Spawning Reserve in Pounds per 1000 Fish Available to the Fishery

LAKE CHAMPLAIN WHITEFISH

(a)- Ten Percent Natural Mortality

Item	Fishing rate (Percent)				
	20	30	40	60	80
(1) No size limit					
Catch	1286	1166	1042	854	722
Abundance	5659	3347	2229	1260	878
Spawning reserve	3818	1721	795	151	14
(2) One age group protected					
Catch	1444	1389	1312	1174	1063
Abundance	6648	4232	3005	1850	1343
Spawning reserve	4788	2459	1348	385	68
(3) Two age groups protected					
Catch	1556	1557	1525	1453	1384
Abundance	7461	4992	3695	2411	1800
Spawning reserve	6003	3534	2237	953	342
(4) Three age groups protected					
Catch	1607	1647	1647	1631	1609
Abundance	7948	5488	4167	2820	2147
Spawning reserve	7948	5488	4167	2820	2147
(5) Four age groups protected					
Catch	1602	1659	1674	1678	1672
Abundance	8017	5603	4294	2938	2250
Spawning reserve	9066	6752	5343	3987	3299

(b)- Fifteen Percent Natural Mortality

(1) No size limit					
Catch	996	963	903	776	678
Abundance	4403	2923	1993	1200	865
Spawning reserve	2666	1274	621	125	11
(2) One age group protected					
Catch	1084	1107	1090	1017	946
Abundance	5053	3460	2579	1675	1250
Spawning reserve	3347	1830	1029	308	58
(3) Two age groups protected					
Catch	1123	1190	1210	1196	1166
Abundance	5478	3922	3031	2071	1584
Spawning reserve	4177	2621	1731	770	283
(4) Three age groups protected					
Catch	1107	1199	1243	1275	1282
Abundance	5594	4117	3255	2297	1788
Spawning reserve	5594	4117	3255	2297	1788
(5) Four age groups protected					
Catch	1048	1145	1196	1239	1259
Abundance	5361	3988	3165	2262	1770
Spawning reserve	6256	4883	4070	3157	2665

TABLE IV (Cont'd.).- Catch, Abundance and Spawning Reserve in Pounds per 1000 Fish Available to the Fishery

LAKE CHAMPLAIN WHITEFISH

(c)- Twenty Percent Natural Mortality

Item	Fishing rate (percent)				
	20	30	40	60	80
(1) No size limit					
Catch	795	812	786	709	639
Abundance	3525	2423	1788	1145	852
Spawning reserve	1864	948	479	98	9
(2) One age group protected					
Catch	836	897	908	881	840
Abundance	3932	2862	2217	1513	1160
Spawning reserve	2348	1369	792	243	44
(3) Two age group protected					
Catch	829	919	959	982	977
Abundance	4101	3101	2480	1768	1385
Spawning reserve	2949	1949	1328	616	233
(4) Three age group protected					
Catch	777	878	934	988	1014
Abundance	3993	3092	2522	1849	1470
Spawning reserve	3993	3092	2522	1849	1470
(5) Four age group protected					
Catch	696	792	847	906	937
Abundance	3621	2829	2321	1716	1371
Spawning reserve	4379	3587	3079	2474	2129

(d)-Thirty Percent Natural Mortality

(1) No size limit					
Catch	541	600	615	601	570
Abundance	2423	1853	1480	1051	828
Spawning reserve	948	519	273	60	7
(2) One age group protected					
Catch	523	602	641	665	660
Abundance	2504	1998	1686	1228	988
Spawning reserve	1198	741	480	151	30
(3) Two age group protected					
Catch	469	555	605	656	675
Abundance	2374	1949	1648	1264	1033
Spawning reserve	1492	1067	766	382	151
(4) Three age group protected					
Catch	392	472	522	582	615
Abundance	2071	1730	1485	1163	961
Spawning reserve	2071	1730	1485	1163	961
(5) Four age group protected					
Catch	310	374	416	468	498
Abundance	1657	1391	1199	945	783
Spawning reserve	2178	1912	1720	1466	1304

TABLE IV (Cont'd.).-Catch, Abundance and Spawning Reserve in Pounds per 1000 Fish Available to the Fishery

LAKE CHAMPLAIN WHITEFISH

(e)-Forty Percent Natural Mortality

Item	Fishing rate (percent)				
	20	30	40	60	80
(1) No size limit					
Catch	393	462	498	518	512
Abundance	1789	1480	1260	973	805
Spawning reserve	479	273	151	35	3
(2) One age group protected					
Catch	340	412	456	499	512
Abundance	1663	1416	1233	983	825
	594	397	257	89	19
(3) Two age groups protected					
Catch	270	333	377	426	450
Abundance	1395	1211	1072	872	740
Spawning reserve	747	563	424	224	92
(4) Three age groups protected					
Catch	197	247	282	327	353
Abundance	1063	935	835	690	590
Spawning reserve	1063	935	835	690	590
(5) Four age groups protected					
Catch	134	168	193	226	245
Abundance	735	649	582	483	414
Spawning reserve	1072	986	919	820	751

(f)-Fifty Percent Natural Mortality

(1) No size limit					
Catch	300	368	410	452	465
Abundance	1400	1229	1095	907	784
Spawning reserve	231	138	79	17	2
(2) One age group protected					
Catch	225	283	322	367	390
Abundance	1125	1006	910	768	670
Spawning reserve	284	195	130	49	11
(3) Two age groups protected					
Catch	153	195	225	264	287
Abundance	806	730	667	571	502
Spawning reserve	356	280	217	121	52
(4) Three age groups protected					
Catch	95	122	142	170	188
Abundance	521	475	437	378	334
Spawning reserve	521	475	437	378	334
(5) Four age groups protected					
Catch	54	70	82	98	109
Abundance	302	276	255	221	196
Spawning reserve	542	516	495	461	436

COMMENTS ON MR. NESBIT'S STATEMENT

By William C. Herrington

Mr. Nesbit has made an excellent argument for fishery management and has argued ably the case for reducing the number of fishermen in order to increase efficiency of operations and adjust the number of workmen and gear to the job to be done. If you will recall the main points which both he and I have attempted to make, I believe you will find that we are in close agreement on most of the general issues considered. We agree that it is desirable to obtain: 1) the optimum yield from the fisheries; 2) the optimum efficiency of manpower and gear use; and 3) the optimum income for the fishermen. I also thoroughly agree with Mr. Nesbit when he states: "Whatever you do, work out your proposals with the fishermen" (and I would certainly add "the fishing industry") "before drafting legislation.——if legislative proposals are drafted wholly by officialdom they will"(I prefer "may") "be defective because officials" (frequently) "do not have access to many of the pertinent economic facts known (only) to fishermen." However, when we begin to consider the place the several objectives should have in a management program and the order of importance to be granted each, our two arguments begin to diverge.

In considering the three objectives I have referred to it seems safe to conclude that the first is peculiar to the fisheries, although comparable in some respects to the objective of management in agriculture. It represents the basic objective of conservation as I understand it. The second objective reasonably might be classed as the ultimate purpose of economics; probably it is desirable in all industries. I believe that it provided the basic concept underlying Technocracy, that idealogy which a few years ago enjoyed such a vougue, but which dropped from attention when the public found that the goal, although beguiling, was distant, and that no one could tell us just how it could be reached. The third objective might be classed as the goal either of economics or social science, or the combination of the two. It is desired by practically all workmen and by no means is confined to the fishery industry. The problem of achieving optimum efficiency of operations and optimum income now may be enjoying a status comparable to the problem of harnessing atomic power. The latter is a fascinating subject for study and experimentation, and its practical realization would have a tremendous effect on civilization, but I have not yet observed that industrialists have begun redesigning their power plants to depend on this source of energy.

In the latter part of Mr. Nesbit's address, he flatly states that the only alternatives facing this Commission are: 1) do nothing; 2) fight inefficiency with inefficiency; 3) eliminate inefficiency by adjusting the numbers of workmen to the job. At the best, this seems to be a rather perverted representation of the case. A more rational and informative approach, it seems to me, is first to determine this Commission's objectives in its approach to fishery problems. For instance, they might be those I have already enumerated: 1) optimum yield; 2) optimum efficiency of manpower and gear; 3) optimum income. The next step is to decide which is the primary and which are the secondary objectives. If you conceive your main function to be conservation, then the first is your primary objective, and the others highly important, but secondary ones. If you conceive your

primary function to be the solution of economic and technical problems, then your primary objective probably will be the second listed objective. If your function is social, probably your primary objective would be the third. I am not quite sure concerning the use of the terms economic, technical, and social, since these fields seems somewhat mixed up. I am merely attempting to show that your approach to the various fishery problems will be conditioned by your decision as to whether your main function is to promote the optimum yield, optimum efficiency, or optimum income.

If you decide to give preference to the first objective--optimum yield, then we aquatic biologists will be able to provide you with definite information concerning the measures needed to achieve these results. The basic principles of fishery management have been established fairly well and with the proper background of facts. The results of specific measures applied to any fishery can be predicted reasonably well either quantitatively or qualitatively. In this field we can assist you as research men have assisted in agriculture. In many cases, perhaps in most, these measures also will increase the efficiency of gear use and will increase the income of the fishermen. Certainly they will enable more fishermen to obtain a livelihood, will increase the production of sea food and will afford more employment ashore and more food for the nation. But the basic purpose of these measures will be to maintain and increase the yield from the fisheries.

If you decide to give preference to the second or third objectives, then we as aquatic biologists can give you no definite information to guide your decisions. As citizens and scientists perhaps we can advise you, but if Dr. Langmuir, retiring president of the American Association for the Advancement of Science, is correct, and science has little application to the field of economics, 1/ then our advice as scientists will be of limited value. If you decide to manage the fishery with the objective of obtaining for the fisherman the income to which he is entitled, you are entering the whole broad field of management economy, which has occupied the attention of the Technocrats, Department of Agriculture planners, the silver block, NRA, Townsend Planners, and numerous others. None of them seem to have solved the problem satisfactorily, but that does not mean that it cannot be solved or that you may not be the ones to do it.

In this discussion I do not wish to imply that the objectives of a managed economy are undesirable. In fact, I believe that most of us will agree that efficient use of manpower and equipment and optimum income are highly to be desired. However, do not let the attractiveness of the prospect and plausibility of the proposed methods blind you to the fact that you would be entering an uncertain and debatable field and that clear-cut results probably would be a long way off.

In contrast, we can at present lay out a clear-cut conservation program making use of methods which are more effective and dependable than those proposed for economic management. I would very much regret seeing a sound conservation program tied to a program for economic management in such a way that the two must succeed or fail together. You may observe that the Department of Agriculture's program to increase crop and meat yield per acre and per farmer, is independent of its program to manage production of certain crops in order to increase the farmer's income. It

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1/ SCIENCE, January 1, 1943

is no more logical to state that a program designed to increase the yield of the fisheries is of no value to the fisherman, the industry, and the nation, unless it is tied up with a program to limit competition and increase income, than it is to state that the use of improved agricultural methods was of no value before the advent of farm income management. I have even heard it questioned whether farm income management, as carried on in many cases (cotton, milk, etc.) in the long run is of value and whether it is justified except as a temporary measure to care for extreme conditions of economic distress.

Now for a few comments on Mr. Nesbit's specific arguments:

He has gone to considerable detail in discussing some of the economic complications that have developed in the Pacific halibut fishery, as the result of the prolonged layover period arising from the catch quotas imposed by the International Fisheries Commission. I wish you to bear particularly in mind that this is the only case where fishery management of the general type we advocate has been put into practice on an important marine fishery. Because it is actually in practice, we have before us all of the various complications that such a program entails. In spite of these complications, the program has been very successful in preventing a further decline in the fishery and the resulting loss of employment to fishermen and shore workers, loss of business to dealers, and loss of food to the nation. Actually, it has increased the catch and employment, and to the extent that the increased employment and income have improved conditions in that area, it has increased the income of individual fishermen. Before management started, the halibut fishermen's incomes were so low that many were turning to other occupations. Now, income has improved to the point where new men are coming into the fishery. Mr. Nesbit prefers to deprecate these gains because the fishery has not yielded the fisherman the income to which he is entitled (whatever that is) and asks you to abandon this method of proven value, for one which at best will have uncertain results. We have no comparable case in which a large marine fishery is being managed by the method and for the purpose proposed by Mr. Nesbit. Consequently, we have no exhibit to which we can point to illustrate the complications which must follow from application of the method. However, do any of you expect that these complications will be any less involved than those I have suggested in my previous statement? I am convinced that if anything, they will be greater than now imagined, just as the economic complications in the halibut fishery are greater than most people expected. To support my opinion, I must refer you to cases in other industries, in which some type of managed economy has been tried as an emergency measure, for instance NRA, the Agriculture Department's cotton and wheat program, milk programs in the several States, etc.

Another concept which has been presented in relation to the proposed method for obtaining maximum efficiency of gear and manpower, deserves further examination. In this examination, I can depart from my role as citizen and amateur economist and return to that of professional biologist. Mr. Nesbit points out that a fishery of relatively low intensity will provide nearly as great a catch as will a fishery of high intensity, and will require only a fraction as much fishing gear and manpower. This will result from the fact that a much greater stock will accumulate when fishing intensity is low and the individual catches will

be much greater. The examples I described to you earlier in figure 2 bear this out, for the maximum catch when the fishing pressure was 80 percent annually, was only 18 percent greater than when the pressure was 20 percent. However, you must bear in mind that this was under static conditions with the annual production of young a fixed amount, regardless of the size of the adult stock. We know that this assumption does not hold except possibly in special cases. In the haddock fishery we have definite evidence which shows that, on the average, the annual production of young is much greater when the adult stock is at intermediate levels than when it is very high or very low. Thus, in the examples shown in figure 2, the 20 percent fishing intensity would not be sufficient to reduce the adult stock to the level where the production of young would be at a maximum. Our best calculations at present indicate that for the Georges Bank haddock stock, the greatest production will be obtained with a vigorous fishery and a minimum size limit of about two pounds, but we are not yet ready to state just what the fishing intensity should be. You will grasp the logic of the argument for a vigorous fishery which prevents any great accumulation of old fish, if you will consider the problem of obtaining the greatest production of beef from a piece of grazing land. Would you operate with a herd of old cattle, keeping sufficient numbers to use all the fodder available? In this case, the total weight increase, that is, production of additional beef, would be limited to the additional meat or fat which they could accumulate. Or, would you sell off the full-grown animals as rapidly as they matured, taking care to keep sufficient only for breeding purposes, and thus save as much of the grass as possible for the rapidly-growing young stock? Our haddock work indicates that managing a stock of fish for greatest production is something like this, although it differs in some particulars and is much more complicated. The results of the work certainly indicate that we should not go too far in advocating a general management program which stresses low fishing rates, until the biological relationships are known better.

There are a number of other statements in Mr. Nesbit's report to which one might take exception. However, it does not seem essential to consider them item by item, for the main issue is one of basic principle and method of attack. Nevertheless, I would like to comment on one statement which Mr. Nesbit words as follows: "This Commission cannot honestly tell a lobsterman that an increase in size limits will increase his income unless the increase is associated with effective measures to prevent increases in the number of lobstermen." I believe that those of you who are well acquainted with the lobster fishery as a whole will be impressed by the fact that such a flat statement could not have been based on any considerable understanding of the lobster fishery and of the conditions which exist in the principal lobster-producing areas. The persistent decrease in the lobster population in practically all areas during the last 25 years, has caused a continuing reduction in the lobster fisherman's income until in recent years he has been working, in most cases, on a vanishing or vanished profit margin (prior to war-stimulated prices). Yet, in a great many communities there is little else that he can do, so he continues lobstering, at least part time. Prevention of further decline in the lobster stock, and increasing that stock through size limits or other conservation measures, will enable many of these fishermen to avoid going on relief. If we can progress to the point of achieving the

optimum catch in the lobster fishery and improve other fisheries in these areas by proper management, a real measure of prosperity will be restored to many small seacoast communities. Would the Commission prefer to tell these people that the lobster fishery is not adequate to support all of the fishermen in the manner to which they are entitled ("accustomed" is not the proper word in this case), therefore only one-half would be granted licenses and the remainder must move elsewhere and find jobs, or go on relief?

In considering this whole problem of increasing income by restricting competition through granting monopolies to a limited number, I am impressed by a statement recently credited in Time to General Patton of our armored forces in Africa. In replying to comments on his propensity for leading his forces into battle by riding a leading tank, he was quoted to this effect: "An armored force is like spaghetti, you cannot push it from behind, you must get up front and pull it." Perhaps increased income also is like spaghetti. Instead of trying to push income up by restricting competition, which pushes men out of successive occupations for the benefit of those remaining and eventually leads to an increasing pool of unemployed, it might be better to apply our efforts to increasing employment, which will provide more jobs and increase competition for available labor, and thus pull men out of the poorer paying occupations and pull income to higher levels. The idea seems worth considering.

As my final statement, I wish to leave you with this recommendation: By all means, approve and undertake a program for conservation management, with achievement of the optimum catch as the primary objective. If you also decide to undertake experiments in managed economy, with optimum efficiency and optimum income as the primary objectives, I urge you to set them up as a separate program which will not jeopardize realization of the first. In view of present progress in the field of aquatic biology, I am hopeful that we shall be well on our way towards realization of the optimum catch within our lifetime. When I look upon the present world and its economic struggles, I am equally hopeful but less sanguine in respect to realization of optimum efficiency and optimum income within the same span of years. Shall we refuse the first unless we can have all?

COMMENTS ON MR. HERRINGTON'S STATEMENT

By Robert A. Nesbit

Mr. Herrington and I agree fully with respect to the importance of establishing minimum size limits wherever it is practicable to do so. We also agree as to the necessity for stabilizing fishing intensity to maintain an optimum fishing rate. But we do not agree as to the methods which should be used to stabilize fishing intensity.

I advocate a new policy of gradual and experimental adjustment of the numbers of operating units to the amount of work to be done. This is primarily a conservation measure. It will make it possible to attain the essential conservation objectives - maintenance of optimum abundance and yield. But in addition, it will (1) permit a close approach to fully efficient use of man power and equipment and (2) permit a well deserved improvement in the earnings and living standards of fishermen.

Mr. Herrington supports the traditional policy which requires that each of variable and excessive numbers of fishermen be required to do less fishing than he is capable of doing, that is, to operate with less than full efficiency. Methods in accordance with this policy can bring about the same, but only the same, conservation benefits as direct limitation of the numbers of operating units. But traditional methods cannot increase efficiency because they consist of the imposition of inefficiency, nor can they increase earnings, for in the long run earnings depend on efficiency.

This is essentially a "share the work" policy. It is the very essence of fishery conservation that there is a limited amount of work to be done. To apply more than the optimum effort is worse than useless, it is destructive. If more than enough fishermen are permitted to engage in the work, it must be shared among them.

Mr. Herrington has given us an excellent critical review of the various methods which have been proposed to establish a stable ceiling on fishing effort while insuring that as far as possible opportunity to work is shared equitably. By pointing out the technical disadvantages of these methods, he has spared me the necessity for doing so. I have offered only a general criticism applicable to all share-the-work methods - without exception they impose inefficiency. For example, Mr. Herrington rightly characterised the method of direct catch limitation as "the most direct precise, flexible, and effective method available". But as I indicated in my original discussion, it is a share-the-work method, hence subject to the general criticism of inefficiency. It may be pointed out that for the few fisheries to which direct catch limitation is applicable, the advantages of directness, precision, flexibility, and effectiveness will be just as available under the new policy as under the old. As applied under the traditional policy, the catch limitation is used merely as a means for determining the datesof annual closed seasons. It will serve equally well for determining the numbers of operating units required. Doubtless the International Fisheries Commission has sufficient information to enable it to estimate within perhaps 10 percent the numbers of

vessels necessary to take the permissible quotas of halibut within fishing seasons of any predetermined length from 3 months to a year. It would be more practical, of course, to approach the final limitation gradually, by reducing the numbers of vessels until nearly a year is required to reach the fixed catch limit.

Mr. Herrington has criticised the new policy on technical grounds and on the basis of social and economic considerations. He has thereby done us a service by pointing out some of the difficulties to be met and dangers to be avoided.

Most of the technical criticisms are necessarily speculative - we don't know in detail how the policy can best be applied to individual fisheries, and we will not know until the Commission takes up the problem with the fishermen and works out with them a workable and equitable plan. In order to offer any advance criticism at all it is necessary to postulate some such procedure as that suggested by Mr. Herrington for bringing about an immediate reduction of 20 percent by drawing lots. And, of course, the validity of the criticism is contingent on the procedure being carried out as suggested. At this stage of the discussion it is necessary to set up a straw man in order to knock him down. I shall not presume to set up the straw man by proposing a detailed program even for the Middle Atlantic region, with which I am familiar, much less for the New England vessel fisheries which I know very little about. When, and if, a program sufficiently detailed for specific criticism is presented for legislative consideration in the several States, it will not be my program but a fisherman's program. I can, as I have in this discussion, indicate general objectives and general biological and economic principles. But each program must be tailor-made to fit the biological and economic peculiarities of the fishery to which it applies. That is a job which can be done only by the men who know the fishery at first hand. All that we conservationists can do is to furnish technical advice in biological, economic, and legal matters. In the end we can learn only from administrative experience whether the technical difficulties are insuperable.

Two technical criticisms require specific answers. In the first, Mr. Herrington points out that a system of fixed license quotas is inflexible. That is true, but it is also true that adoption of the system will eliminate much of the need for flexibility. It is the frequent change in numbers of operating units which makes it necessary to change regulations and laws under present policies and practices. The great technical merit of the fixed catch limit is that it automatically adjusts the length of the open season to compensate for changes in the numbers of vessels. If, however, the numbers of vessels be fixed the total fishing rate will change very little and the fishery will attain stability with very small variations in the length of the open season and with a steady seasonal flow of products to the market.

Fixed license quotas will also eliminate most of the variation in fishing intensity caused by fishermen who operate irregularly and less industriously than they are capable of doing. When fishing becomes more profitable, an incompetent or lazy fisherman cannot afford to retain a license with a potentially high income value. He will sell it to an able fisherman. Eventually the fisheries will be freed from the disturbing influence of in-and-outers and part-time operators.

Although for most fisheries it is stability that we seek rather than flexibility, for some fisheries there is a special need for flexibility. These are the fisheries in which marked year-class dominance is associated with a very brief period of availability to the fishery. Examples are the fisheries for the Pacific salmons, for shrimp and for blue crabs. A fixed fishing rate under-utilizes the abundant year classes by allowing more fish, shrimp, and crabs to spawn and die than are needed for reproduction. The same rate may leave too few spawners from the poor year classes. Such problems must be dealt with individually.

It may be noted in passing that a fixed catch limit would exaggerate this difficulty. Fixed catch limits determine the fishing rate with a high degree of precision only for species which are not subject to marked year class dominance and which have a long life span.

It is possible that need for flexibility will arise for other species in which year class dominance is not associated with a brief period of availability. The haddock may prove to be such an instance. Herrington[1/] has shown that too many spawners are as objectionable as too few. It may prove necessary to remove large year classes quickly even at the cost of poor utilization in order to prevent interference with production of young by too large stocks of adults. In this particular instance it will not be difficult to make the necessary adjustments for Georges Bank, by permitting a temporary diversion of effort from more distant banks.

In the second criticism, he has pointed out that where several banks are accessible to a large fishing fleet, limitation of the size of the fleet would not protect the nearby banks from overfishing. This is quite true, because the whole fleet would work on the nearby banks and would not resort to more distant banks until the nearby banks were depleted. In such instances the use of catch limits for individual banks would provide a solution. The use of such limits as an auxiliary administrative measure would in no way invalidate the necessity for limitation of the numbers of vessels in the general fleet. An alternative method would call for licensing a group of vessels for each bank, the numbers authorized for each depending on its productive capacity. Some vessels would have exclusive access to the nearby banks where operating costs are low and others would be restricted to the more distant banks where operating costs are high. At first thought this would appear to be extremely inequitable but in fact the objections are practical rather than ethical. To see why this is true it is necessary to pass on to a discussion of Mr. Herrington's criticism of the proposed policy on the basis of social and economic considerations.

The criticisms presented under this heading are related more or less directly to an alleged necessity for arbitrary fixing of income levels. That is, Mr. Herrington fears that we would necessarily let ourselves in for administrative responsibility for matters best left to the free play of economic forces. If it were true, as Mr. Herrington fears, that such a necessity is inherent in the program, it would indeed be indefensible.

1/ Herrington, Wm. C. A Crisis in the Haddock Fishery, U. S. Bureau of Fisheries, Fishery Circular No. 4, 1941.

But in fact we are proposing only to eliminate the inefficiencies which prevent the creation of additional income, leaving the selection of fishermen and the distribution of income to exactly the same economic forces which operate in other industries based on natural resources. We have no responsibility, nor can we afford to assume responsibility for individual earnings nor for differences of income in different fisheries or regions.

In order to make it clear why no such necessity is inherent in the policy and need not develop in the program, it is necessary to review some of the technical features of the economics of the extractive industries (i.e., those based directly on natural resources). The validity of the following is subject to the provision suggested in the original discussion, that licenses, once acquired, be transferrable, i.e., salable in a free market.

From any business, there are 4 kinds of income: (1) Wages of management (the amount which the owner could earn as an employee of some other business), (2) profit (the reward for risk), (3) interest on the value of the instruments of production (interest on the investment in man-made producers' goods), and (4) economic rent (interest on the investment in land, mineral deposits or other natural resources). It is characteristic of all of the extractive industries except fishing that income from economic rent is a relatively high proportion of total income. For example it has been estimated that five-sixths of the money invested in farms in the United States is capitalized economic rent and that only one-sixth represents the value of buildings, stock, and farm equipment. Nearly all of the investment income from farming is economic rent. Again, the value of coal or iron deposits or of timber land, is high compared with the value of the mining or lumbering equipment. But economic rent scarcely exists in the fisheries. There are a few exceptions to this general rule, notably where riparian rights are recognized, where rights to particular pound-net locations are recognized and are transferable and where oyster grounds are privately owned. Economic rent is practically non-existent in the fisheries because it is destroyed by inefficiency. In an economic sense, then, we propose to create or to restore a source of real income which will take the form of economic rent and which will be distributed among fishermen as such. This is of great practical importance because it relieves us of the necessity for administrative concern with the distribution of income. We can see why it will do so by seeing how it works in other extractive industries. As everyone knows, some farms are better than others. All farmers, all miners, and all lumbermen get about the same prices for their products. Yet even the marginal farms, mines and timber tracts continue to be operated in competition with the best farms, mines, and timber holdings. We seldom question the equity of the system whereby some farmers own good land and have large incomes, while others have poor land and low incomes. For after all the difference in incomes is a difference in investment income. Let us suppose that the farmer who owned the best farm sold it and with part of the proceeds purchased a very poor farm, investing the difference in a business enterprise involving about the same risk as farming. His total income would remain unchanged. He would make less from farming but returns from his investment would make up the difference. Similarly suppose the man owning a very poor farm acquired enough money to buy a better farm. He would be just as well off if he invested his money in some other way. In other words, most

of the difference between low income farmers and high income farmers is a difference in ability to acquire enough money to establish an investment income.

As economists explain it, the function of economic rent is to equalize costs between producers with varying degrees of natural advantage. If the spread between operating costs and market price is great, as it is with good land near markets, the price of the land becomes high enough so that the increased investment cost just balances the higher operating costs on marginal land.

In the past we have accomplished a similar equalization of costs in fishing, either by damaging the best fishing grounds by overfishing, which increases cost, or by imposing artificial inefficiencies (conservation measures) on the better fishing grounds, and these also increase costs. In either case we have destroyed a source of real income, which can be restored and distributed in the form of economic rent. As Mr. Herrington points out, doubtless a lobster license will be more valuable in some counties in Maine than in other counties and in any county a license to operate 200 pots will be more valuable than a license to operate 100 pots. But the more valuable licenses will be more expensive, and a lobsterman will have the same option to invest his money in a better license as has a farmer to invest his money in a better farm.

In the light of the foregoing discussion let us return to a point made above. It was stated that objections to licensing groups of vessels for each bank are practical rather than ethical. We have seen that an analogous situation exists in all other extractive industries, and that the income differences between individual operators are differences in investment income and not in earned income. It could be argued, indeed it often is argued, that investment income, based on ownership of natural resources and the instruments of production is not legitimate. But we are not concerned here with socialistic reform of existing agricultural and industrial policy. On the contrary, we are seeking to secure for the public and for the fishermen the same economic benefits which accrue from private ownership of land.

The practical difficulty arises from the fact that most of the vessel fisheries are operated on a share basis, that is, the employees share the financial risks inherent in operation without participating in the capital investment. If some vessels are assigned exclusive rights to nearby banks, the investment charges will be much greater for such vessels than for those licensed for more distant banks. This would necessitate drastic changes in the methods of adjusting employee compensation, and would require extended and difficult labor negotiation. It would be necessary either to (1) make vessels fully cooperative with each member of the crew participating in the investment, (2) put all employees on a straight wage basis, (3) adjust the percentage share so that the vessel owner is compensated for his investment in the license as well as for investment in the vessel.

As I indicated in the original discussion, part of the economic rent should be recovered for the public, enough at least to meet administrative and research costs. But it will not be wise to go too far in the direction of recapturing it for the public. For two reasons some must be left among fishermen.

In the first place, fishing is an unusually speculative business. If license fees were set high enough to absorb nearly all of the economic rent in average years, they would become an impossible burden in poor years, just as the high interest charges on over-capitalized economic rent became an impossible burden on many farms during the prolonged agricultural depression following the first world war. It is probable, of course, that some licenses will be bought with borrowed money, so that to some extent this difficulty would arise in poor fishing years even if license fees were kept moderate. But license rights would not, I think, be looked on favorably as collateral by banks, and in any case, not all fishermen would be burdened with fixed charges for debt.

In the second place, it is necessary to leave enough income from economic rent with the fishermen to perform the essential function of automatically equalizing costs between nearby and distant fishing grounds and between operating units of different capacities. The more closely we attempt to adjust such differences by fixing license rates the more closely we approach the very real dangers of arbitrary bureaucratic administration against which Mr. Herrington so eloquently warns us.

Now let us discuss Mr. Herrington's "alternative method". The proposal itself, as exemplified by a suggested application to the halibut, is not an alternative at all - it is a very good illustration of the principles which I have been advocating for more than two years. We have already seen that a fixed catch limit may be used either to determine the length of the open season or to determine how many vessels are needed on a full-time basis. If used for the former purpose the program is conventional, if used for the latter purpose the program becomes an experiment under the policy which I advocate. Obviously the experiment could be checked and the program stabilized at any intermediate stage between the present stage in which a large fleet is idle much of the time and a final stage in which a small fleet would be hard pressed to catch the limit in a full year. And, of course, the economic loss would also be intermediate, i.e., proportional to the amount of idle time.

But what he says about the proposal merits some comment. Just as I do, he makes a distinction between conservation objectives on the one hand and social and economic objectives on the other. But he more than implies that these objectives are incompatible and that we must choose between them. For example he states: "I am also concerned as to whether the use of this method will disrupt the general conservation program to the extent that the productivity of the fisheries will be reduced".

It should scarcely be necessary to reiterate that this method provides the basis for a general conservation program. Considered strictly as a means for reducing fishing intensity and increasing catch and abundance, elimination of unnecessary operating units will be just as effective as any other method of reducing fishing intensity. But is it not an advantage of the method, that it promises to confer important social and economic benefits too?

The following sentence also requires critical examination: "If this Commission wishes to pioneer a managed economy in the fisheries, to insure every man the income to which he is entitled, and at the same time

insure the benefits of an effective conservation program, I believe that the following general approach will be most effective, productive, and clear cut." Here again we find the same unwillingness to recognize that the primary objective is conservation and that the social and economic benefits, however important, are secondary and additional. We do not propose a "managed economy" but a managed fishery. One of the desirable results of this particular method of management will be a substantial increase in the income of fishermen - an increase caused by creation of a new source of income which cannot be created in any other way. As has been explained above we need accept no managerial responsibility for distribution of this new income. It will be allocated among fishermen, not by untried and dubious "managed economy" practices but through the operation of the well proved economic principles which control distribution of income in other extractive industries.

Finally, let us dismiss details and technicalities and seek to review the problem as a whole, and on a national scale. Only by doing so can we hope to view it with a sound sense of proportion. Only by so doing can we fully appreciate its urgency.

In round figures, the fisheries of the United States and Alaska yield between four and five billion pounds of fishery products with a value to producers of about $100,000,000. It is conservative to estimate that technically sound conservation practice will increase production and yield by at least 10 percent. This can be accomplished either by conventional methods or by methods based on limitation of gear. But at this point similarity ceases. Under the present conditions of unlimited competition costs tend to equal the market value. Income is limited to wages and to a small and uncertain yield on investment in producers' goods. This will still be true if the conservation benefits are accomplished by conventional methods. In this event there will be an increase in quantity from about 5,000,000,000 pounds to about 5,500,000,000 pounds and an increase in value from about $100,000,000 to about $110,000,000. But there will be no net gain, because increased operating costs (in the form of additional and socially functionless employment) will automatically absorb all of the increase in value.

On the other hand, if we accomplish our purpose by economically sound methods, we will accomplish the same increase in quantity and value of the product. But the original operating and investment costs will be reduced by at least 20 percent, that is, from about $100,000,000 to about $80,000,000. There will then be a net gain of $30,000,000 representing the difference between the increased value ($110,000,000) and the reduced cost, ($80,000,000). In other words the industry is now spending $100,000,000 to catch $100,000,000 worth of fish. But by spending only $80,000,000 it could catch $110,000,000 worth. It does not matter whether we think of it as a waste of $30,000,000 or a waste of $30,000,000 worth of manpower -- it is still waste.

These rough estimates of increase in catch and decrease in costs are based on Figures II, III, and IV. It will be noted that the curves indicating catch are relatively insensitive to changes in management practice, but that abundance, which is (or can be made to be) a measure of cost, is very sensitive to changes in the fishing rate.

We have seen how much we have to gain, and we have seen that it can be gained only if we boldly adopt a new policy based on sound economics. No one can predict with assurance the results of a major social experiment, but this much is certain: - an annual loss of at least $25,000,000 a year will continue until we do make a successful experiment. Every year at least $25,000,000 worth of man-power which might be used to forge the instruments of war or to create the satisfactions of peace are being wasted in senseless duplication of effort. Can we afford not to make the experiment? Can we even afford to delay?

BIOGRAPHICAL DATA

In introducing the principal speakers of the forum discussion, the Chairman referred to the following biographical data:

WILLIAM C. HERRINGTON

Born: Harvard, Illinois.

Education: California Institute of Technology and Stanford University, A.B. 1927; graduate study, University of Washington and Harvard University.

Employment: During schooling: in shipyard, surveying, lumber mill, longshoring, fish canneries, and electrical engineering maintenance; temporary scientific assistant U. S. Bureau of Fisheries 1924-1927, tuna and clam investigations in California. After graduation: research assistant International Fisheries Commission 1927-1930; North Pacific halibut fishery; aquatic biologist, U. S. Bureau of Fisheries 1930-1937, North Atlantic haddock fishery; In Charge, North Atlantic Fishery Investigations, Fish and Wildlife Service, 1937 to date, directing staff and engaging in investigations of haddock, mackerel, redfish, flounders, lobster, and other fisheries of New England shore and offshore areas.

ROBERT A. NESBIT

Born: Tekamah, Nebraska.

Education: University of Nebraska, A.B. 1919; graduate study, University of Wisconsin; Harvard University, M.A. 1931.

Employment: Forest disease control with U. S. Department of Agriculture; instructor in zoology, University of Wisconsin; seaman on Great Lakes; high-school teacher, Chicago; biological supply business, Chicago; aquatic biologist, U. S. Bureau of Fisheries, 1926-1937, engaged in study of the mackerel and weakfish fisheries and other shorefisheries; In Charge, Middle Atlantic Fishery Investigations, Fish and Wildlife Service, 1937 to date, directing staff and engaging in investigations of shad, striped bass, flounder, and other shorefisheries, Long Island to Florida.